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DEFENSE SYSTEMS MANAGEMENT REVIEW. VOLUME 2, NUMBER 2. SPRING 1--ETC(U)
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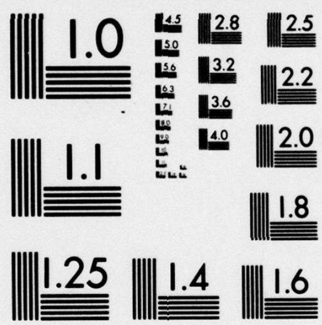

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DEFENSE SYSTEMS MANAGEMENT REVIEW

SPRING 1979
VOLUME 2
NUMBER 2

Joint Program Management

The *Defense Systems Management Review* is published quarterly by the Defense Systems Management College, Fort Belvoir, Va. 22060, and is intended to be a vehicle for the transmission of information on policies, trends, events, and current thinking affecting program management and defense systems acquisition.

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, 5285 Port Royal Road, Springfield, Va. 22151, and the Defense Documentation Center,
Station, Alexandria, Va. 22314. When ordering from the Defense Documentation Center,
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DEFENSE SYSTEMS MANAGEMENT REVIEW

SPRING 1979
VOLUME 2
NUMBER 2

Volume 2, Number 2. Spring 1979, Joint Program Management.

11 1979

12 106p.

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DEFENSE SYSTEMS MANAGEMENT REVIEW

SPRING 1979
VOLUME 2
NUMBER 2

Joint Program Management

SUMMER 1979 DSM REVIEW

Configuration Management

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Foreword

Rear Admiral Rowland G. Freeman III, USN
Commandant
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Joint program management offers an exceptional challenge to the acquisition manager, whether it be a joint U.S. military service program, a joint Federal agency program, or a joint multinational program with the United States and foreign governments as partners. Regrettably, most joint programs do not become joint when the operational requirement or need is determined but, rather, after considerable research and development has been done independently by the newly aligned partners.

The word *joint* does not necessarily mean togetherness. Most joint programs are the result of forced "marriages," so to speak, that take place in a fairly emotional environment. Effective management under these conditions requires a comprehensive understanding of the needs and requirements of each of the services involved, but it also requires an understanding of the differences in logistic support, financial management, program management philosophy, organization, and test and evaluation techniques. If the joint program involves another Federal agency or a foreign country, the problems are even more complex. In any case, continual compromise must be made in most areas of the acquisition process, all the while recognizing that the ultimate product may not completely satisfy all the intended users. Financial and configuration management will probably present the greatest challenges. Clearly, joint programs require the very finest in management skills, particularly from the program manager of the executive, or lead, service.

It is apparent that we will see many more joint programs in the future because of their potential for providing a satisfactory product at substantial cost avoidance. This will require a solution to one of our more significant problems: the great lack of "corporate memory" in the joint program management field, meaning that lessons learned from one joint program have seldom been passed along to the next. Much of this issue of the *Review* is devoted to joint program management and offers specific examples from which lessons can be drawn. It must be recognized, however, that what worked in one joint program may not work in another.

Along these same lines, the Defense Systems Management College has been tasked by the joint logistics commanders to publish a *Joint Program Management Guide*, in which examples of successful procedures, as well as of those which failed, will be illustrated. In this regard, we need to hear from you who have been involved in joint programs at any level, and, most particularly, we need to learn where you have found solutions to your most difficult problems of joint program management.

In a normal project, the project manager operates in an environment of uncertainty. In a joint program, the environment of controversy is added. Be prepared!

...and a final word

As many of you know, I will retire from active military service on 30 April 1979 after serving for two years as Commandant of the Defense Systems Management College. During that time I have been particularly proud of the progress of the Defense Systems Management Review. *I believe we have improved both the format and content and have succeeded in increasing its effectiveness as a tool of acquisition management. I am hopeful that in the future we will be able to continue to publish articles addressing every facet of the acquisition problem, articles that will form the basis for written debate on important acquisition issues. I personally intend to contribute management-oriented articles from time to time in the future, and I urge you to do the same. This is the only way we can hope to continue the high quality of this publication.*

Rear Admiral Rowland G. Freeman III, USN

7 The Looking-Glass World of International Programs

Lieutenant Colonel David A. Appling, USA

Two quotations from the masterworks of Lewis Carroll illustrate two major facets of international rationalization, standardization, and interoperability (RSI):

> "It's a great huge game of chess that's being played—
> all over the world...."
>
> —*Through the Looking-Glass*

> " 'You may seek it with thimbles—and seek it with care;
> You may hunt it with forks and hope;
> You may threaten its life with a railway share;
> You may charm it with smiles and soap—' "
>
> —*The Hunting of the Snark*

RSI *is* a game—in the mathematician's sense of a formal situation involving players whose interests do not entirely coincide—and our understanding of the tools for achieving RSI is often as imperfect as that of Carroll's hapless Snark-hunters. Herein, with the help of Lewis Carroll, I offer a few lessons learned during 5 years of personal involvement in international tank main armament (cannon plus ammunition) programs, in the hope of providing some thimbles and forks useful to "snark-hunters" in other programs.

Threat Perception, Doctrine, and Requirements

> "I know what you're thinking about," said Tweedledum; "but it isn't so, nohow."
> "Contrariwise," continued Tweedledee, "if it was so, it might be; and if it were so, it would be; but as it isn't, it ain't. That's logic."
>
> —*Through the Looking-Glass*

The first difficulty encountered by the RSI practitioner is that the parties involved in an RSI program, whether it be an evaluation, a standardization of existing hardware, or a codevelopment, are seldom trying to get to exactly the same place, or to satisfy the same requirements. In the Trilateral German-British-American Tank Main Armament Evaluation Program of 1973-1975, the three countries sought to standardize on main armament for their three future tanks, and an *ad hoc* working group was formulated to seek such a solution. Notably

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Lieutenant Colonel David A. Appling, USA, is Assistant Project Manager for 120mm Systems, Office of the Project Manager for Tank Main Armament Systems. He is responsible for the technology transfer of the German 120mm gun and ammunition for use with the Army's XM1 tank, and for related development efforts. He has held such RSI program positions as Deputy U.S. Chairman, Tripartite F.R.G./U.K./U.S. Tank Main Armament Evaluation; Chief, XM1 Tank International Division; and Assistant XM1 Program Manager for Main Armament. Lieutenant Colonel Appling holds a B.S. degree in mechanical engineering from the Massachusetts Institute of Technology and an M.S. degree in applied mechanics from the University of California at Berkeley.

absent from this body's terms of reference was standardization of threat or doctrine. Clearly, an armed force's perception of the threat drives its doctrine, and the two together drive its hardware performance requirements. In this case, the working group sought a common hardware solution to three different requirements driven by three doctrines in response to three different perceptions of the threat. The working group did reach a common recommendation, but it was not adopted, in large part because of the requirements problem. If future standardizers are to avoid Tweedledum and Tweedledee dialogue, they should treat international agreement on threat and doctrine as a first principle—at least insofar as it affects the specific RSI problem being considered.

National Perceptions of RSI

> "When I use a word," Humpty Dumpty said, in rather a scornful tone, "it means just what I choose it to mean—neither more nor less."
>
> —*Through the Looking-Glass*

Another potential impediment to successful RSI is the fact that the various parties to a program often have very different ideas about just what successful RSI, or terms such as "two-way street," should mean in practice. After many years of dominating the NATO weapons market, the United States is making a determined good-faith effort to fairly consider the flow and, when warranted, adopt foreign-developed items. Roland and the German 120mm tank gun are two highly visible examples. However, in the event of war, the United States must be the arsenal of NATO, and since the U.S. is separated from European NATO by 3,000 vulnerable miles of water, it stands to reason that we must develop an on-shore production capability for such systems.

From the U.S. perspective, on-shore manufacture under license is consistent with the two-way street concept. The perception in, say, Germany is somewhat different. To Germany, the two-way street requires a two-way flow not only of technology and money, but also of jobs. The sensitive U.S. practitioner of RSI must understand that employment is a more sensitive, and far more emotional, issue in Germany than here, and further, that under German labor law, employers may not lay off workers due to idle capacity as U.S. employers may and do. Three lessons can be learned here:

- Don't expect your European counterpart to be overly impressed with favorable balance of trade considerations, or with U.S. willingness to exploit his technology, if European jobs are being lost or jeopardized in the process.
- Expect vigorous resistance to U.S. requests for unrestricted or minimally restricted export rights, even with handsome compensation.

- Your negotiations will go better, faster, and more smoothly if the U.S. position contemplates buying a portion of its requirements off-shore. This is, of course, easier said than done, as the jobs issue is by no means negligible in the U.S. However, in my opinion, our commitment to the two-way street concept implies that we should be more forthcoming on this point than we have been to date.

Law

> ...I've found
> An inconsistency or two.
> —*Sylvie and Bruno*

A frequent cause of difficulty in international program negotiations is the wide variance between U.S. and European law which, of course, differs from country to country.

An example may serve to illustrate the type of problem encountered. In the spring of 1977, early in the U.S. Army's final evaluation of main gun candidates for future application to its XM1 tank, a senior German defense official made an oral offer to his United States counterpart along the following lines: The German Government offers the United States Government all its transferable rights in the 120mm tank main armament system without charge.

This offer was made in complete good faith and the German Government delivered on it—under German law. Considerable misunderstanding occurred, however, because the offer, made under German law, was widely interpreted in the U.S. under American law.* Under German law, the German Government acquires no proprietary rights in defense materiel developed with government funds. It does acquire a so-called "usage right," which, among other things, permits the government to transfer, grant, or cause to be granted to certain other countries the right to manufacture and use the materiel for their own defense purposes. It does not allow transfer for foreign military sales or security assistance purposes, because the right to grant export licenses is vested solely in the contractor. Financial terms for licensing are at the discretion of the contractor, with the government recouping a portion of royalties collected. The government may also impose a separate charge for transfer of the usage right.

The offer as stated, therefore, covered only the right to manufacture for U.S. defense use, with a waiver of all charges by the German Government. The offer said nothing at all about export rights or about financial terms to be imposed by the contractor—indeed, it could not legally do so. After selection by the U.S. of

*Specifically, under the "General Terms and Conditions for Development Contracts with Industrial Firms."

the German 120mm weapon system, 13 months of hard negotiation were, in fact, required to obtain a satisfactory license for the U.S. The lesson here is clear: It is absolutely mandatory for international program managers to acquire a reasonable businessman's understanding of applicable law in all countries involved.

> ...the Judge said he feared
> That the phrase was not legally sound.
> —*The Hunting of the Snark*

It is equally clear that a well-qualified international lawyer, or legal team, with a solid knowledge of applicable foreign procurement and patent law and regulation is indispensable in the negotiation phase of RSI programs. There is a widespread misconception that RSI negotiations are international social affairs leading to gentlemen's agreements sealed with a handshake. Unfortunately, nothing could be further from the truth. At anything more definitive than the agreement-in-principle stage, RSI negotiations are hard, tough, business talks analogous to contractual negotiations, and require the same knowledge, expertise, and fortitude. Further, in contrast to our Defense Acquisition Regulation (DAR), which has a standard clause for virtually every occasion, the typical European analogue is far shorter and much more general. Therefore, specific legal phraseology not at issue in U.S. defense contract negotiations can become highly significant in international agreements, particularly in licensing agreements. It is extremely important to have a legal team who can ensure that "the phrase is legally sound." We in the U.S. Department of Defense are fortunate in the large number of highly qualified procurement and patent lawyers at our disposal. As yet, however, all too few of these gifted practitioners are well versed in foreign jurisprudence. Our strong commitment to RSI implies that we in the Defense Department should give high priority to strengthening our capability in this vital area.

Conduct of Negotiations

If one were writing an "Introduction to International Negotiations" it would be difficult to improve upon the Red Queen's celebrated advice to Alice:

> "Always speak the truth—think before you speak—and write it down afterwards."
> —*Through the Looking Glass*

Applying this valuable advice to international negotiations would, however, require further elaboration, such as provided below.

DEVELOP CONFIDENCE

The negotiator must be scrupulously honest and, where circumstances permit, frank and open as well. The record clearly shows that programs between allies

are extremely difficult to get off the ground until the respective national teams develop confidence in one another. My experience is that American negotiating teams, in particular, tend to be viewed with considerable suspicion during the opening steps of the mating dance. There is, for better or worse, a deeply ingrained suspicion that the giant U.S. defense establishment will do its best to steamroller its smaller counterparts—economically, doctrinally, and every other way. The fall of the dollar against major European currencies has apparently done nothing to relieve this mind-set. Frankness and openness help to build confidence that the U.S. team is in fact truthful, intellectually honest, unbiased, and looking for solutions which are best for the Alliance rather than for the United States or its industry.

WATCH YOUR LANGUAGE

Considerable care must be taken in the formulation of national statements, both oral and written. The negotiator who does not make his statements precise may well have to eat his words, amid considerable embarrassment for him personally and possibly for his government. Alternatively, he may have to live up to them, possibly to substantial disadvantage. In this regard, it is well to remember that very few English discourses longer than a few words translate *exactly* into other languages. This is particularly true for complex and convoluted verbiage, such as the "Federalese" which we all use even if we don't like to admit it. The more carefully a national statement is formulated, the more likely it is to be understood in translation as intended, and the less likely will be the necessity for "clarification" later. This includes "translation" from American into British English—there are numerous differences in terminology, tone, and substance. By way of example, the expression "to table a proposal" has exactly opposite meanings in British and American, and I can cite one meeting in which the British and American delegations talked past each other for a quarter of an hour on this point.

WRITE IT DOWN

Minutes of meetings, memoranda for record, etc., are indispensable. If possible, minutes of formal meetings should be prepared and signed jointly, because this ensures agreement on the responsibility for action items and provides a reasonable degree of assurance that the problems of understanding noted above have, in fact, been solved. The utility of minutes, and the importance attached to them, is attested to by the long hours of haggling which are usually devoted to them at the conclusion of international meetings. Here are some specific lessons learned in this regard:

- Allow several *hours* at the end of a meeting schedule for agreement on minutes. Make every effort to obtain an agreed upon, signed paper before

adjourning. The probability of obtaining agreement later in under 2 or 3 months is very small.

- Designate a delegation member to write the minutes (if the host nation) or to assist in writing them (if the visitor). Ideally, this individual should have no other duties during the meeting.
- Don't record every word, but rather key statements, positions, agreements, and disagreements.
- Accept that the wording of national statements is at the sole discretion of the proponent delegation.
- Recognize that each delegation usually has certain points which it must get into the minutes for home consumption.
- Accept a basic linguistic fact of life: A document must be written in *some* original language, and no document written elegantly in one language can be translated with legal precision and retain its elegance in the new language. (This principle holds *a fortiori* for more formal papers such as licensing agreements; during the 120mm tank gun licensing negotiations, considerable time and effort had to be expended, not very profitably, negotiating changes to the German verbiage so that it would read more like standard legal English.)
- If formal minutes are inappropriate, or if circumstances preclude them, a national memorandum for record should be prepared and sent to the other delegation(s) for information and comment. (This does not, of course, preclude a separate memorandum for national eyes only, where appropriate.)

Some other points on the conduct of negotiations which are not included in the Red Queen's advice:

- Never go to an international meeting alone.
- Never negotiate without the proper expertise on your team. If key experts are unavailable, inform the other delegation(s) in advance that in those areas of expertise you are prepared only for non-binding discussions.
- Deliver what you promise, and promise only what you can deliver. To do this it is clearly essential to ascertain in advance how far your writ of authority extends. Recognize that an explicit commitment by you in an international meeting will be viewed as a commitment by your government.
- Recognize and take into account national differences in freedom of action given to negotiators. Because of the size and dispersion of the U.S. weapon system acquisition community, U.S. negotiating delegations typically have considerable flexibility—more so than those of any other nation with which I have dealt. In Germany the acquisition community is small, the chain of command short, and the span of control narrow by comparison to those in

the U.S. Therefore, coordination of positions is relatively easy, and negotiators do not need, and do not receive, a great deal of freedom of action. Such lack of flexibility can be maddening to a U.S. negotiator; but the latter should remember that on completion of the negotiation the German team will have essentially pre-staffed the agreement. In the U.S. a long, tortuous staffing process probably awaits the agreement, a process which will be at least equally maddening to the German side.

- Where appropriate, defer issues which become contentious until later in the meeting, remembering that thorny issues tend to lose their thorns as airplane time approaches.
- Perhaps most important of all: Remember that your opposite numbers across the table have nearly 30 years of experience in NATO RSI negotiations, and that we are the "new kids on the block" in this business. Use this fact in two ways: learn from your counterpart, and don't ever (in the superb German phrase) *verkaufen ihn fuer dumm*—"sell him for stupid."

Unity of Command—Precedent

> "I don't think it *ever* happened before, that any one had to take care of two Queens...at once!"
>
> —*Through the Looking-Glass*

Unity of command is a military maxim which has two important applications to international negotiations. First, the negotiator must recognize that the relative chain-of-command length and span-of-control breadth, discussed above, provide his European counterpart with a significant advantage. For example, the Under Secretary of Defense for Research and Engineering; the service Assistant Secretaries for Research, Development, and Acquisition; the service Deputy Chiefs of Staff with that responsibility; and the U.S. joint logistics commanders all have the same German counterpart, the Director of the Armaments Division in the Federal Ministry of Defense. The same applies, of course, at lower levels and in other countries. The U.S. negotiators have often been surprised (but, given the above situation, they should not have been) to have an RSI agreement pertaining to unrelated materiel of a different service quoted as a precedent. Like all good negotiators, our counterparts can be relied upon to cite those precedents that favor their positions rather than those that do not. Clearly, the U.S. negotiator must be prepared to handle such situations, and must be able to determine whether the precedent cited is correct, is apposite to his negotiation, and is to the United States' advantage.

We in the Defense Department are beginning to do a better job of systematizing lessons learned in RSI programs; one thing we clearly need to do in this area is

to analyze, publish in digest form, and widely disseminate the terms and conditions of RSI agreements throughout the Defense Department down to the project-manager level. Such digests should contain a summary of the background leading up to the agreement so that irrelevant precedents can be readily identified. This would require an enormous amount of work, but it would appear to be one of the most beneficial lessons-learned exercises the Department of Defense could conduct in the RSI field.

A second application of "unity of command" deals with who should conduct detailed RSI negotiations and manage RSI programs. There is a very natural tendency to legislate RSI from the top down. However, in the end, the same person who is responsible for conducting national acquisition efforts for a given piece of hardware will have to live with whatever international agreements are concluded. The clear implication is that the domestic program manager should conduct the detailed RSI negotiations and manage the U.S. portion of the resulting RSI program. Similarly, the team which negotiates U.S. domestic program contracts should be deeply involved in negotiations with foreign contractors, including contractor-to-government licensing agreements, which are contracts under U.S. law.

Interpreters and Translators

> "Language is worth a thousand pounds a word!"
>
> —*Through the Looking-Glass*

> "I said it in Hebrew—I said it in Dutch—
> I said it in German and Greek:
> But I wholly forgot (and it vexes me much)
> That English is what you speak!"
>
> —*The Hunting of the Snark*

Interpreters and translators* do not, of course, receive a thousand pounds a word, but it is at least arguable that their services are worth that much and more. If a proper rendering into English of a few hundred German words on patent rights turns out to save the U.S. Government millions of dollars in patent infringement claims, what per-word value should be put upon the rendering?

The role of the interpreter in international programs is not well understood in the United States. Unless one has had direct experience in multilingual programs and negotiations, there is a natural tendency to believe that anyone who is bilingual is an adequate interpreter. In fact, the international interpreter needs not

*Interpreters render oral discourse from one language into another; translators render the written word. The two skills are not the same and should not be confused.

only a native command of both languages, but many additional qualifications, such as:

- *Real-time interpreting ability, as at the United Nations.* The skill required for simultaneous interpretation takes many years to acquire and many aspirants never acquire it;
- Knowledge of the appropriate technical and military terminology in both languages;
- Sufficient technical comprehension to explain complex technical ideas and tactical concepts in another language that does not necessarily contain an exactly equivalent concept;
- The ability to convey the true semantic flavor of a statement, as opposed to mere literal translation, which can often be misleading;
- Finally, the ability to serve as political and cultural advisor to the head of the delegation, which clearly can be the key to a successful negotiation.

During international meetings and discussions, furthermore, the delegation leader normally needs his own interpreter and should not ordinarily rely upon one provided by the other country. The reason is twofold: to ensure that his own statements are being translated into the other language without alteration of the semantic sense, and to have an independent check on the interpretation being provided by the other team. The first point is probably the more important, and implies that an international program manager should try to work with the same interpreter repetitively and, if possible, have the interpreter on his own staff.

Translators are equally important in an international program. While the necessity for translations is well recognized, the amount and complexity of translation effort is not adequately appreciated. In particular, the time to produce even a rough translation—15 to 45 minutes per page is a reasonable figure—and the effort required to turn the rough literal translation into a finished, technically correct, and legally precise English version, are usually rather surprising to the uninitiated. Again, like his cousin the interpreter, the successful translator for a weapon system acquisition program must be part engineer and part soldier, as well as all linguist. The lesson here, of course, is to get good interpreters and translators. Unfortunately, this is much easier said than done in the U.S. defense establishment. Germany and France maintain corps of professional civil-service interpreters; Great Britain has a hybrid system of a few in-house civil servants supplemented by a substantial "stable" of free-lance interpreters. The latter are hired on a piecework basis but have standing security clearances. By contrast, the U.S. Department of Defense has virtually no system, although a modest start on one is now being made at the Army's Foreign Science and Technology Center.

Generally speaking, an international program manager in the United States must either try to hire his own linguists from outside the Civil Service system (in

which case the hiree will almost certainly not have simultaneous interpreting capability and will require extensive on-the-job training); borrow from those few programs possessing trained linguists; or rely upon free-lancers, who normally have neither program background nor security clearances. If this particular "lesson learned" is to be fully exploited, it seems clear that the Defense Department must adopt a more systematic approach to the problem of interpreter/translator support.

Administration, Security, and Logistics

"...however legal it may be...
This style of business seems to me
Extremely inconvenient!"

—*Sylvie and Bruno*

International programs have their own peculiar bureaucratic headaches and red tape with which the practitioner must learn to cope. These have mainly to do with travel, visit clearances, and security regulations.

Regarding travel, the international program manager must cope with regulations designed in a different era, when an official business trip to Europe was a major, rather than commonplace, event. In the Army, regulations require application 60 days in advance of the trip, and approval at major-command level. Such a requirement is perhaps reasonable for non-programmatic visits, but is impossible for the manager of a fast-moving program to deal with. The solution reached by my office was to obtain blanket delegation of authority to direct travel outside the Continental United States on program-related matters, including authority to deal directly with U.S. defense attache offices and theater headquarters regarding visit clearances. Currently, the office has this authority for travel to Belgium, France, Canada, Germany, The Netherlands, and the United Kingdom. Initially, the major Army commands had grave reservations about such a blanket grant, but the procedure has now been working well for 5 years with no problems of any significance. It allows the Army's XM1 tank program and tank main armament personnel to visit Europe as dictated by program requirements, with only that lead time required by host country authorities.

Unfortunately, the reverse problem—U.S. clearance for foreign visits on program-related matters—has not proved so amenable to solution. The U.S. system is basically designed to keep unnecessary foreign visitors out rather than to ensure that necessary foreign visitors are let in. It makes no official distinction between visits for international program management purposes and mere information-gathering exercises.

The clearance process is very tightly controlled from the top down and can be set in motion only by an official request from the respective foreign embassy.

While admirable from the standpoint of safeguarding information, the existing system is only marginally responsive to international program needs and occasionally creates both delays and embarrassment. Recently, a critical international test milestone had to be slipped pending issuance of a visit clearance for German engineers. Foreign personnel have on occasion flown to the United States to participate in multilateral tests, only to "cool their heels" in a hotel while awaiting their clearance.

The solution would appear to be to charter international program managers to approve official programmatic visits by counterparts, subject to certification by national authorities of their security clearance and need-to-know and also subject to concurrence by installation commanders concerned. Such a delegation of authority would, on track record, speed up the clearance process by a good 3 weeks, and time is money, particularly in international programs. Until such a solution is reached, the practitioner is advised to plan well ahead and to encourage his counterpart to submit blanket requests through his embassy for long-term clearances covering all foreign personnel and all U.S. government and contractor facilities involved in the program.

Release of classified information presents an analogous problem. Regulations implementing the National Disclosure Policy are explicit regarding the release of U.S. defense information, but do not specifically provide for the case of jointly owned data. Therefore, these data are normally subjected to standard U.S. release procedures, meaning that a U.S. program manager does not ordinarily have the authority to release a counterpart's own classified data to him, let alone U.S. data. This constraint is onerous and occasionally embarrassing, but under current procedures the program manager must live with it unless he is provided a specific *ad hoc* grant of release authority. Again, the ideal solution from a program manager's standpoint would be a specific, clearly defined charter grant of release authority for data specifically pertaining to his program. Precedent does exist for this sort of grant, e.g., the former German/U.S. Main Battle Tank-70 program.

Personnel Utilization

"Curiouser and curiouser!"

—*Alice in Wonderland*

A final remark on international program management: As RSI programs become more and more prevalent, the Department of Defense is developing a considerable amount of expertise in international business. To my knowledge, however, in neither the civilian nor military personnel management systems is there any provision for identifying and tracking people with specific international experience. Given the great importance of international programs and the

vigorous high-level emphasis on RSI, such a gap in the management structure is indeed becoming "curiouser and curiouser." We need a system to ensure that these highly qualified people—people superbly trained via the school of hard knocks—are used repetitively in key RSI programs, so that lessons once learned will not have to be learned again. Our counterparts in Europe do this, which offers an added benefit to repetitive RSI tours—being able to do business with friends and counterparts from previous programs, by-passing the months-long period required to develop mutual confidence and rapport. The benefits are obvious, and the implementation costs would be minimal. Clearly, if we are serious about RSI—and we are—we should put some such system into effect.

Conclusion

> "But, now that you've stated the whole of your case,
> More debate would be simply absurd."
>
> —*The Hunting of the Snark*

I have endeavored to present a few lessons learned during several years of intensive, nearly continuous, international programs and negotiations, together with some modest recommendations both to individual practitioners of the art and to the services at large. If there is one overall conclusion to be reached, it is that there are no panaceas in the RSI business, and no overall cookbook solutions which can be applied to every RSI problem. And if there is one overall lesson to be learned, it is that international program management *is* a different, and more complex, game than national business, very much like three-dimensional chess as compared to two. In fact, there are some additional rules and bylaws which are only revealed to the player when he actually moves on the board, not unlike Alice's experiences in Looking-Glass World. One wonders what sort of international program manager Lewis Carroll would have made! ‖

19 Managing Less-Than-Major Joint Programs

Captain Phillip E. Oppedahl, USN
Colonel Henry R. Passi, USAF

There have been many studies on, and much has been written about, the acquisition of major systems within the Department of Defense. At the same time, we continue to see a great deal of emphasis being placed on joint-service programs, e.g., the cruise missile, the advanced medium range air-to-air missile (AMRAAM), and the high-speed anti-radiation missile (HARM). It appears that this emphasis will continue as defense dollars continue to shrink and as joint roles and missions are refined. Dr. Malcom R. Currie, former Director of Defense Research and Engineering (DDR&E), emphasized the point in his statement to Congress regarding the FY78 research, development, test and evaluation program, when he said:

> The time is long past when we can have the luxury (and waste) of individual Service developments for every requirement. In addition to fiscal realities, the complexities of modern systems and requirements for intimately integrated and interdependent tactics between Services dictate that we increasingly approach requirements and systems developments on a truly joint-Service basis.[1]

The ideal of more cost-effective systems through joint development programs is an admirable goal; therefore, it is incumbent upon the joint development program manager to understand the environment within which the programs are managed, and the pitfalls which could nullify this goal.

There are more than 60 ongoing joint development programs and, as might be expected, the major systems attract most of the attention. Still, there is much to be learned from and about the non-major programs. For that reason, this paper will focus primarily on management of less-than-major programs, more specifically, the management of joint Navy/Air Force munitions development programs.

Department of Defense system acquisition programs are categorized as major or less-than-major programs based on the estimated cost of the acquisition. In

1. The DOD Program of Research, Development, Test and Evaluation, Statement by the Director of Defense Research and Engineering to the 95th Congress, First Session, 18 Jan 1977, p. 1—16.

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general, a program is designated as major if the development cost is expected to exceed $75 million or if the total procurement cost is in excess of $300 million.[2] It is a little-known fact that many of the less-than-major system programs are estimated to exceed the dollar threshold established by DODD 5000.1. This usually occurs because of large aggregate production quantities rather than high development costs.

From a management standpoint, the principal distinction between major and less-than-major programs is the level of program review and authority. For major programs, the Secretary of Defense is the final acquisition authority. As acquisition costs diminish, decision authority is vested at progressively lower management levels within the service components.

Regardless of the cost or scope of the acquisition program, it must satisfy critical criteria established by the services, the Department of Defense, and the Congress before the system can be operationally deployed. In this regard, management of a less-than-major project differs little from a major system acquisition. But, a principal area of divergence does exist in the autonomy afforded the manager of a less-than-major program in exercising management authority. Such a manager frequently finds significant latitude in his decision authority because the relative scope and cost of a single program neither requires nor commands intensive high-level management review.

A joint-service development program usually connotes a formalized agreement between two or more services to share the responsibility for development and production of a hardware item for common employment. Such an acquisition concept is not new, and has resulted in spectacular successes such as the AIM-9L, as well as less-than-successful efforts such as the TFX. The rationale for joint agreements is difficult to fault. Substantial cost savings should be realized by eliminating duplicative research and development, and by capitalizing on volume procurement. In view of the relatively high cost of current weapon system acquisition programs and an expectation of higher costs for the complex systems of the future, it is reasonable to expect that joint-service weapon system projects will become increasingly prevalent.

Despite doctrine and mission differences, there are sufficient similarities in such areas as aircraft systems, tactics, and potential combat targets to lead the Navy and the Air Force increasingly toward joint weapon and weapon system development programs. This is particularly true in less-than-major programs which, owing to their general-purpose nature, have a high potential for satisfying multi-service needs. These services are now engaged in development of five less-than-major munition system programs: second generation fuel air explosives

2. "Major System Acquisition," DOD Directive 5000.1.

(FAE II), GATOR air delivered land mine, BIGEYE binary chemical bomb, air inflatable retarder (AIR), and multiple stores ejector rack (MSER). (It should be noted that the Army is a significant participant in the GATOR and BIGEYE programs.) Other potential joint efforts which are forecast but which have not reached a formal definition stage include a common electric bomb fuze; an enhanced family of general-purpose bombs; an increased-performance cluster munition dispenser; a decreased-sensitivity general-purpose bomb explosive fill; and a hard structure penetrator warhead.

Joint Program Initiation

The appropriate less-than-major munitions development programs are designated as joint-service efforts by the services, with the concurrence of the Armaments/Munitions Requirements and Development (AMRAD) Committee. This committee is an advisory agency of the Under Secretary of Defense for Research and Engineering and is composed of senior military representatives working within the framework of the joint service harmonization agreement. One of the committee functions is to review and assess individual service statements of operational requirements to determine the potential for joint-service use. Such an assessment is an iterative process conducted in coordination with the services, and frequently involves the negotiation of system characteristics to enhance the potential for multi-service application. Based on the results of this review, the AMRAD Committee, in its advisory role, provides guidance to the services regarding joint-program potential.

From this guidance comes the designation of the lead service in the development effort. There are no specific criteria for the selection of the lead service. The selection may be made on the basis of the dominant user; the service with the most technical expertise; or simply, it may be made on the basis of bureaucratic reasoning. The functional responsibility of the lead service is obvious—to take primary responsibility for the direction and accomplishment of the joint development effort. The lead service defines the program by producing a coordinated joint service operational requirement (JSOR) and a joint development plan (JDP), which is approved by the services, and promulgated by the lead service.

Through prior agreement, the lead service is also responsible for determining fiscal resource requirements for a joint-service program and for ensuring the availability of those resources. Within this agreement, the lead service funds all development activity, with the exception of items that are unique to an individual service. For example, in a joint effort, the Navy would expect to fund the test and qualification tasks related to the carrier environment, the results of which would be of little value to the other service.

Initiation of a joint-service development program should most logically stem from agreement among the services on a common need for an item. Ideally, such an agreement should be reached during concept formulation, and before the demonstration and validation phase (pre-milestone one). Rarely does an operational requirement conceived by one service completely satisfy the needs of another. The production of a joint service operational requirement is usually an exercise in compromise as each service negotiates for specific, desired characteristics.

Parameters such as size, weight, cost, operational environment thresholds, and logistic impact are but a few of the areas which must be considered and for which fundamental agreements must be reached. From experience we know that such negotiations have a greater potential for success if they are conducted and consummated prior to the fabrication of the demonstration model.

Representing the technical community, the service program managers are deeply involved in the program formulation, as well they should be, because they are ultimately responsible for execution of the program. The JSOR is normally a statement of required capability, which, while lacking in specificity, clearly establishes the bounds and scope of the resulting technical approach. The JSOR should be as specific as possible, and either it or the specifications should become more and more specific as the program progresses. The joint-program manager must set aside service prejudices and resist service pressures throughout the development program, but particularly during preparation of the JSOR. If he does not maintain objectivity, the program will be subject to the two extremes in JSOR, that is, only identifying those requirements common to both services, or accumulating the requirements of all the services, no matter how incompatible. In the first case, it is unlikely that the development will be suitable for either service; in the latter case, the system will, in all likelihood, be too complex and too expensive, thus defeating the original intent of the joint development.

From time to time in the past, attempts have been made to harmonize an item which had already progressed well into the validation phase of development, or which had already begun full-scale engineering development. In very few cases did this harmonization prove successful to satisfy one of the fundamental objectives of joint-service development—reduced acquisition costs.

A case in point is the Air Force's improved mechanical fuze (IMF) development program. The IMF was of interest to the Navy because it contained a clutch mechanism feature which was not available in the Navy's principal mechanical bomb fuze, the M904. However, the joint-service engineering team which was established to determine the feasibility of Navy participation in further IMF development found that the IMF, as designed, was not compatible with Navy shipboard requirements. Redesigning the fuze to meet unique Navy requirements

would have resulted in significantly higher end-item costs for the Air Force, and would have unduly complicated the original program. The Navy thus chose not to participate in the development, and instead designed a simple cover for the M904 which accomplished most of their objectives.

Another incident occurred in 1974. At the urging of the DDR&E Principal Deputy, the Navy and the Air Force were requested to evaluate the potential for satisfying their respective requirements for an improved electric bomb fuze through the harmonization of requirements. At that time, the Navy was well into the development of the FMU-117 and the Air Force was in a similar position with its FMU-112 fuze. The objective was to explore the potential for adapting either the FMU-112 or 117 to satisfy both services' needs. Again, a joint technical team was established to evaluate the potential for commonality. While it was determined to be technically feasible to redesign either fuze to satisfy the other service's requirements, the resulting increased development and procurement cost, without a commensurate increase in performance capability, made this a less attractive alternative than for each service to complete independent development and initiate separate procurements.

These two examples illustrate the need to harmonize requirements prior to the commitment by a service to a specific design approach. In both cases, the decision to harmonize requirements came so late in the program that efficient harmonization could not be effected.

Service Relationships

The joint development plan (JDP) is the basic management document for a joint-service program. When approved, it represents a contract between the participating services and the Department of Defense for the conduct of the development effort and for the goals to be achieved. While there is a specific format for a JDP in that the program is to follow the policies and procedures of the lead service, each JDP is tailored for the applicable project and includes the essential elements of a decision coordinating paper.[3]

The lead service is responsible for initiating the JDP and for obtaining coordination and concurrence by the participating services. Included in the JDP are such essential items as management relationships and responsibilities; system description, including functional requirements and characteristics; acquisition strategy, detailing the scope of effort to be performed by service laboratories and private industry; logistic concepts; and a schedule with well-defined milestones and management decision points.

3. "Management of Multi-Service Systems, Programs, and Projects," AFSC/AFLC Reg 800-2, AMC Reg 70-59, NAVMATINST 5000.10A.

The initial edition of a JDP may lack specific detail because of the several undefined qualities which exist in the early stages of any development program. However, the first drafts of program documents should include specific details concerning personnel interface, financing, and requirements. Generalized statements tend to reflect that all parties have a "general" idea of what is going on when, in fact, their ideas may be totally different. The inclusion of precise detail challenges people to think, creates less misunderstanding and, if some of the specifics are found to be totally unworkable, encourages people to insist on changes to the program and program documents. Generalized program documents rarely need changing, but then they are rarely used. The development program is structured to progressively provide any detail that may be lacking in the initial phases of the program. It is understood, and expected, that the JDP will be revised on a periodic basis, or when a major program perturbation occurs. Any one of the participating services can initiate a revision to the JDP by obtaining concurrence from the other services.

While service regulations stipulate that a joint program will adhere to the policy and procedures of the lead service, the experience gained over the past several years has led to effective tailoring and to the application of existing service and Department of Defense system acquisition procedures in the joint-development arena. As a practical matter, such tailoring meets the needs of all services concerned, not just the lead service.

Management responsibility for less-than-major munitions development programs resides with the Naval Air Systems Command Program Manager for Armament, and with the Air Force Systems Command Deputy for Armament Systems. For those programs in which the Air Force is the designated lead service, the Air Force Deputy for Armament Systems, Armament Development Test Center, functions as the central point of contact and decision authority, with the Navy Program Manager for Armament acting as his deputy. The reverse is true for Navy lead-service programs.

Each service program management office is staffed with engineering specialists, and has access to acquisition specialists within the respective systems commands or field activities to provide essential program support. These specialists are afforded direct liaison with their other service counterparts within the policy guidelines established by the program managers.

The key elements in effective program management are the establishment and maintenance of a timely, responsive, and comprehensive informal and formal communications network. Such a network is particularly important for Navy and Air Force less-than-major weapon system joint-service program management because of the geographical separation of the two service program management offices: the Air Force Deputy for Armament Systems being located at the Armament Development and Test Center, Eglin AFB, Florida; and the Navy Program

Manager for Armament being at Naval Air Systems Command Headquarters, Arlington, Virginia. Because of this separation, special emphasis is placed on ensuring an open and candid flow of information between the program managers on all aspects of the various joint-service programs.

An informal direct communications network between these program managers has proven to be most effective in identifying potential problem areas, and in obtaining mutual agreement on the management actions necessary to resolve them. A fundamental precept of the working relationship established between the Air Force Deputy for Armament Systems and the Navy Program Manager for Armament is the dedication to resolve problems and conflicts at the program management level. It has been learned from experience that the elevation of a conflict or disagreement is rarely beneficial to the progress and success of a program, and should be exercised only when resolution is clearly beyond the capabilities of the program managers. The importance of this informal direct communications network between program managers cannot be overemphasized. However, because of the many players in joint-service programs, it is equally important that major informal agreements be formally documented and transmitted to all participants.

A breakdown of communications can, and has, produced serious impacts on joint-service programs. As may be expected, competent technicians, working to resolve a problem, quite frequently approach the problem from several aspects and arrive at different conclusions. Such situations are evident in the normal progress of a joint-service development program. If ignored, these differences frequently result in a divergence which erodes confidence in the program and diminishes the potential for success. It is the job of the program managers to assess the merits of competitive ideas, arrive at a decision, and act accordingly. These management exercises are most successful when they are conducted in a timely and expeditious manner and on an informal and direct basis, regardless of geographical separation.

Program management has the equally important communications responsibility to ensure that higher level authorities of participating services are advised of the program status, particularly when major deviations from prior project agreements or direction occur. Except in unusual cases of compelling urgency, this formalized communication is carried out by means of status and budget reviews, as well as by program documentation updates or revisions. More immediate action to inform higher authority is required whenever a program fails to meet a critical performance milestone or whenever cost thresholds are breached. It is insufficient for the program manager to merely inform higher authorities of such situations; he must provide management alternatives which could resolve the issue, along with a recommended course of action. The program manager is

expected to use all the resources at his disposal to resolve problems prior to elevating them to his superiors.

Thus, the establishment and maintenance of an effective informal and formal communications network is vital to the success of joint-service development programs. It provides the basis for confidence that each service is working for successful accomplishment of the objective; assists in resolution of problems at the appropriate level; and, it assures that all parties are informed on the program's status.

Blending Service Requirements and Testing

One of the most challenging aspects of managing joint-service programs is bridging the gaps between the services, i.e., satisfying requirements stemming from such areas as planned operational environment, system safety, logistics, maintenance, and the scope of test and evaluation needed to demonstrate these qualities.

Almost equally as challenging is understanding the language and terminology. The Navy has technical evaluation (TECHEVAL) rather than development test and evaluation, and the two terms are not exactly synonymous. The Navy has "approval for service use" akin to, but not the same as, the Air Force production recommendation; the Army, Navy and Air Force use terms like OT II and OT III, but they do not all mean the same thing. Each service has developed specific requirements which it imposes on the characteristics of a system before accepting it for operational use. In many instances, these requirements are added to strictures which the Department of Defense has applied to the system acquisition process. The program manager must fully understand not only his service's requirements, but also those of other participating services to ensure that project decisions do not adversely impact on the ultimate joint-service use of the system.

Differences among the services relating to the operational employment environment create the greatest impact on joint-service programs. Forward-deployed, bare-based concepts create significantly different requirements than does the carrier environment. Likewise, items which may be vitally important to the Navy because of the carrier environment are of only passing interest to the Air Force. One of the significant factors is the physical size of the weapon system item. A principal Air Force consideration is whether the weapon will fit on the aircraft. The Navy shares this concern, but must also consider dimensions because of requirements for below-deck magazine storage, accessibility to and compatibility with munitions elevators, and handling on the flight deck.

The climatic environment to which the weapon system may be exposed imposes specific requirements. Both services may be required to employ a system in climatic extremes ranging from the arctic to the desert. An Air Force bare-base

environment may dictate that the weapon withstand prolonged storage exposed to the elements, while the Navy must consider the effect of exposure to the salt spray or fog encountered in the sea environment. Packaging for sea or carrier on-board airlift also imposes specific, rigid requirements not necessarily shared by the other service.

These are but a few of the myriad details which must be fully considered by the manager of a joint-service development project. Since one of the principal objectives of joint system acquisition management is to fulfill the needs of the services at an affordable cost, extreme caution must be exercised to ensure that all potential impacts of seemingly insignificant cost/performance trades are well understood, and that none is undertaken which may preclude the operational employment of the system by one of the participating services.

Determinations of the ultimate military worth of a joint developmental weapon or weapon system, and the decisions to produce the item for operational use, are affected greatly by the results of comprehensive test and evaluation by the services' independent test and evaluation agencies—the Navy Commander Operational Test and Evaluation Force, and the Air Force Test and Evaluation Command. These organizations evaluate the operational suitability and effectiveness of a system by testing it in a realistic environment.

The criteria used to evaluate a system are stipulated in the joint service operational requirement and/or the joint development plan and include performance (speed, range, accuracy), operator function, system reliability, maintainability, other system compatibility, and logistics supportability. Since the test agencies are responsible for the full and complete assessment of the performance of a system in relation to its expected performance, it is imperative that nonessential performance parameters be avoided.

Test and evaluation of a joint development program is approached in a manner similar to a single-service development effort. A joint test and evaluation master plan is produced which defines the scope, responsibilities, objectives, and resource requirements governing the conduct of both development test and evaluation and operational test and evaluation. It may also include follow-on test and evaluation and production acceptance test and evaluation, as appropriate. The joint test and evaluation master plan is supported by specific, detailed test plans developed by the testing agencies from each service. Development test and evaluation is the responsibility of the development agency and is conducted to assess the technical capability of a system in relation to defined parameters as promulgated in the joint service operational requirement.

The program manager of a joint-service development project is responsible for the coordination and production of the joint test and evaluation master plan. The lead service is responsible for providing resources needed to conduct all

testing activity except that which may be defined as unique to a participating service. Because test resource requirements (test items, test range facilities, aircraft sorties and hours, simulators, data collection and data reduction, personnel and personnel travel) are so important, it is incumbent on the program manager to ensure that test plans are carefully structured to minimize the requirement for assets, and to avoid redundant or duplicative testing. It is essential for the program manager to have one service understand and buy-off on another service's tests. A fertile area to consider is reliability, since each service has its own unique test methods.

As with the other aspects of joint-service development program management, the planning activities associated with system test and evaluation must be conducted with considerable coordination between the field supporting activities, the test agencies, and the service deputy program manager. This coordination is best effected by utilizing the formal and informal communications network established for the program. The greatest potential for development program perturbation resides in the test and evaluation phase. The avoidance of the pitfalls which have adversely affected programs demands exceptional effort by the program manager.

Budgeting

The constant nightmare of a program manager is a funding decrement or a budget cut in the program. Program plans and development performance are no less a concern of the joint-service program manager than they are to the manager of a single-service development program. The basis for such activity in either case is the availability of funding. In one regard, the position of the program manager for a joint development program is more tenuous than that of the single-service manager, for he must be wary of funding problems arising not only from within his service, but within the other participating services as well.

The joint development plan, as a management tool, assigns responsibilities to the services and their support agencies for the accomplishment of specific, usually interdependent, tasks. While it is generally true that the lead service is responsible for full funding of the program (with the exception of service-unique requirements which contribute to the final configuration of the joint-service item), all of the requirements and their supporting funding must be coordinated in the development of the item.

For example, assume that the item being developed is a new general-purpose bomb. Because of unique safety considerations, one participating service requires the use of plastic bonded explosives as the bomb fill. Because this is a unique service requirement, it is agreed that the requiring service will fund the qualification of this new explosive. In this example, if the requiring-service funding support

does not sustain the planned qualification schedule, the entire program must be delayed. Such situations can, and do, arise.

While there have been proposals to "fence" resources for joint-service development programs to minimize such occurrences, the services have resisted such efforts in order to retain flexibility in resource allocation. When funding shortfalls occur, the program manager must exercise his total management acumen to minimize the impact through project restructuring, reprogramming, or rescheduling. Unfortunately, most of the less-than-major joint-service conventional weapon development programs are relatively austere, providing minimal flexibility and maneuvering room for the program manager. In most instances, insufficient resources result in project delays which are costly and which degrade program momentum.

Summary

The foregoing provides but an overview of the intricacies of managing less-than-major joint-service development programs. Owing to the conflicting management, technical, and doctrinal approaches of the services, the program manager of a joint development program is afforded a multitude of unique opportunities to exercise both management skills and diplomacy; each is equally important for mission success.

A single-service development organization is viewed as a two-dimensional matrix organization with its attendant management problems. In a joint development program, a third dimension is added by the second service. This affords the program manager one of the rare occasions in which it is possible to coordinate diverse groups into a cohesive, directed effort, while at the same time benefiting from the exposure to the talents and expertise of these groups. Finally, joint-service project management provides a unique sense of accomplishment when the fruits of the effort are put into the hands of the service operators. ‖

Representation and Responsibility in a Tri-Service Program

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Dr. William C. Wall, Jr.

Tri-service system responsibility adds still another dimension to the multi-faceted world of project management. It mandates that the project manager (PM) not only concern himself with his own service's requirements, but also that he be equally sensitive to the needs of the other services. Tri-service system responsibility also requires a high degree of teamwork among participants and additional channels of communication. This article explores some of the more significant aspects of unique service interfaces in tri-service system project management.

The Project Manager, Ground Laser Designators (GLD) Project Office, U.S. Army Missile Research and Development Command, Redstone Arsenal, Alabama, is assigned tri-service responsibility for all ground laser designators. Generically, GLD are those devices that provide reflected target energy and the control link for laser semi-active guided munitions. Currently, the product line comprises two major configurations—short-range and long-range designators.

The short-range configuration consists of the lightweight laser target designator (LTD) being procured to meet U.S. Army and U.S. Air Force (USAF) needs, and the tripod-mounted modular universal laser equipment (MULE) being developed for the U.S. Marine Corps (USMC). The long-range configuration is the ground laser locator designator (GLLD). It is transitioning from engineering development to production to meet U.S. Army extended designation range requirements. While commonality of componentry and support equipment is sought among all designators as a matter of design principle, commonality with LTD and the GVS-5 rangefinder is the prime driver in the design of the MULE.

The Players and Their Primary Roles

In the GLD arena, there are four principal players. First, there is the GLD project manager. It is his responsibility to ensure that the development, production, and fielding of assigned GLD are consistent with the service needs and are accomplished without breaching cost, schedule, or technical performance thresholds. He must organize the work, secure the necessary resources, and keep the program on track. And, conversely, he must always be prepared, based on cost, schedule, and performance variations, to recommend termination. In sum, he is totally responsible for the successful acquisition of GLD for all three services.

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Second, there is the U.S. Army user community. Prior to the fielding of a system, user interest is represented primarily by the U.S. Army Training and Doctrine Command (TRADOC). During the development phase, TRADOC is concerned with development of operator and maintenance personnel training programs; format of manuals; establishment of tactical doctrine, tactics, and techniques for employing the system; participation in development and operational testing; and interaction with the PM on technical performance of the GLD in relation to required operational characteristics.

On-site TRADOC interests are coordinated by a TRADOC liaison officer. As the system nears deployment, the using combat forces become increasingly more active, through direct interaction with the PM, particularly in the areas of technical performance and integrated logistics. The units using the GLD are essentially concerned with system usability and supportability. In the case of GLD, the issues are totally new from both technological and capability points of view. Accordingly, many virgin areas of concern have to be, and are being, resolved.

The USMC is the third player in the GLD arena. Since the Army is managing the development and acquisition of MULE, the USMC is directly concerned with essentially the same considerations for MULE as the PM—the successful acquisition of the MULE within established cost and schedule boundaries with a design that meets or betters all required operational characteristics. Due to the magnitude of its total effort, Headquarters USMC assigned a liaison officer to the Missile Research and Development Command to coordinate USMC areas of interest with the command staff. Additionally, a USMC officer is assigned directly to the GLD project office for all GLD matters.

Finally, by virtue of its procurement of a limited quantity of LTDs, the USAF is the fourth major military player in GLD acquisition activity. Interaction between the project office and the USAF occurs at a much higher program level for LTD than the parallel interaction between the project office and the USMC for MULE. At present, only summary-level cost, schedule, and technical performance criteria are specified and monitored by the USAF. This relationship exists primarily because of the nature of the LTD acquisition. At this time the USAF does not have a liaison officer assigned at either the command or project office level. The PM, in essence, acts as a surrogate for USAF on-site presence.

Implications of Relationships

The PM relationships with the Army user and user representative (TRADOC) are typical of most single-service ventures where the PM's service and the using service are the same. There is also frequently the common bond of prior association. Typically, the project office has military personnel assigned who have

served in combat units. Additionally, the PM himself normally has had tours with user elements. As a consequence, military personnel assigned to the project office inherently have user interest at heart and provide significant user-oriented input into system design concepts.

The PM's task is made more complex in the tri-service situation, however, because of the requirement for maximum technical commonality in the MULE; the need to allocate appropriate program costs properly and equitably among the programs; and the necessity of meeting schedule commitments to the other services. Interface occurs through such media as correspondence, telephone conversations, visits between each other and jointly to third-party locations, and inclusion of TRADOC in the major decision-making mechanisms such as the production in-process review.

The PM relationship with the USMC, in the case of the MULE program, is micro in scope and is facilitated by the USMC officer who has been organizationally integrated into the project office. He is the assistant PM (APM) for MULE, and his assigned duties would be no different if he were an Army officer assigned to the project office. The assignment of the APM for MULE to the GLD project office is a direct infusion of USMC thinking, doctrine, and policy into the mainstream of project activity. The APM for MULE works side-by-side with all other members of the project office.

The USMC APM's presence also enhances closed-loop communication. He is an integral member of two groups. He is an accepted member of the project group by virtue of his credentials and the compelling force of his own capability. He is an accepted member of the USMC community by virtue of the uniform he wears and the effectiveness of his performance. The APM serves as an umbilical, in both directions, between the project office and all interested elements of the USMC.

The relationship between the GLD PM and the USAF is, by comparison, more macro in scope. Predominantly accomplished by correspondence and formal reports, the acquisition of LTDs by the project office for the USAF basically represents an addition to both the procurement quantity and the associated program funds. All major technical specifications of the LTD are firm at this point in its life cycle, so the acquisition is equivalent to an off-the-shelf procurement for the USAF.

PM as Integrator—USMC APM as Facilitator

The primary function of any PM is to integrate all program elements in a manner that will control costs within budget, maintain the prescribed schedule, and achieve required system operating characteristics. Command level liaison officers have a similar, but much more indirect, mission while the responsibility of the USMC APM assigned to the project office falls somewhere in between these two.

If the PM is classified as an integrator, then the USMC APM certainly must be characterized as a facilitator. The PM as integrator and the USMC APM as facilitator share common objectives for the same system in a congruent time frame. Both must operate in a dynamic environment driven by unexpected problems and shifting program priorities. Both are uniquely accountable for the accomplishment of their assigned responsibilities.

This is not to suggest that any service without liaison officers is in trouble. If the relationship is a straight buyer-seller relationship, as exists between the GLD project office and the USAF for LTD, a full-time representative at the project level is normally not necessary. On the other hand, if the program requires buying service interaction at the micro level, on-site representative may be an absolute necessity.

Teamwork—Key to Success

Based on GLD experience, tri-service project management is a viable approach to the acquisition of multi-service application systems. GLD experience suggests that the major management schemes involved fall on a continuum. The activities of the proponent service appear to be on one side of center, with those of a pure "buying" service on the other. Please note that these two situations are not necessarily the bounds of the continuum, although, pragmatically, they may well be just that. The assignment of a sister-service APM or liaison officer to the project office and/or the responsible command falls in between these two examples.

It is my own perception of this key consideration of joint-service ventures that the degree to which a sister service participates in the day-to-day affairs of the project involved is primarily a function of the complexity of the acquisition as perceived by the sister service, and their need for near real-time information. Certainly, the physical presence of a liaison officer from a sister service offsets the occasional paralysis of abridged communication, but for some acquisitions the assignment of such an individual may not be an affordable alternative. In these cases, the PM as surrogate is a logical consideration.

In any event, teamwork is the key to success. A PM is faced, at best, with an inordinately complex task, and tri-service ventures add to that complexity. GLD experience suggests, however, that, through teamwork, the challenges can be successfully met. ‖

Coproduction: The U.S. F-5E in Taiwan and Switzerland

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Captain R. Kenneth Bowers, USAF

Coproduction of defense systems by two or more countries naturally offers more opportunities and presents more challenges than a "normal" program of direct procurement. Besides helping a country to meet its defense requirements, coproduction could also mean increased utilization of labor, the transfer of advanced technology, and enhanced national prestige. The decision to enter into a coproduction program thus involves a nation's foreign and domestic policy objectives. For example, funds used ostensibly for national defense will in a coproduction program, have favorable impact in other areas of national interest. In like fashion, funds set aside for other purposes can be used to augment defense needs.

After taking these considerations into account, two countries, Taiwan and Switzerland, made the decision to undertake coproduction of the Northrop F-5E Tiger II aircraft. This paper will address the management of those two coproduction programs. Despite their differences, there are many similarities in these two programs, occasionally giving one a sense of *déjà vu.*

The Programs

Taiwan has established an extensive coproduction program at its government production facility, Aero Industrial Development Center (AIDC), at Taichung. The Taiwan F-5 program, code named "Peace Tiger," provides a good example of blending a foreign military sales (FMS) program with a government-to-industry direct contract.

The U.S. Air Force provides approximately 80 items of government furnished equipment (GFE) including engines, engineering change proposals, and management services as defined in various letters of offer and acceptance signed by the United States and Taiwan. Taiwan contracts directly with Northrop Corporation for the airframe and equipment to complete the aircraft, as well as for tooling, training, and technical assistance required to deliver F-5s to the Taiwan Air Force.

The Taiwan facility manufactures, from raw materials, the entire forward fuselage, trailing edge flaps, ailerons, dorsal cover, nose gear door, wing leading edge extension, and rudder. Production and manufacturing tasks were phased in over a 2-year period with AIDC adding more tasks as its capability increased. The Peace Tiger programs began in the summer of 1973, and the first F-5E was delivered in 1975. The AIDC has consistently remained at least one aircraft ahead of its schedule.

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Contrasting to Taiwan's program, the Swiss "Peace Alps" program is not quite so ambitious, that country's requirements being different from Taiwan's. The Swiss federal aircraft factory, Eidgenossischen Flugzeug-Werk (F+W), at Emmen, coassembles F-5Es from complete shipsets provided by an FMS agreement. The Swiss do not manufacture or fabricate any parts but accomplish the final assembly tasks and acceptance testing usually done by Northrop's Palmdale facility. Northrop provides technical assistance and assembly tooling under a contract with F+W.

The Peace Alps program was the result of a thoroughly extensive evaluation which began in 1973. A letter of offer was signed in late March 1976. The first Swiss-assembled F-5E was "rolled out" in August 1978.

Management Interface

In the initial stages of an approved program most of the effort is between the foreign government and the aircraft contractor. This is in keeping with the U.S. Government policy of not marketing for private industry. The U.S. Air Force may be aware of the contractor's activities, but no action is taken until a country requests a letter of offer.

That being said, the Swiss took a novel approach in that they signed letters of offer for USAF support of their evaluation activity. This included the demonstration of the F-5's capabilities in Switzerland in the summer of 1974. Thus, the USAF actively participated in the program from the very beginning.

In a foreign military sales case, as in the Swiss program, it is essential that the USAF be involved. This involvement must extend to the working level, i.e., system program office (SPO) and air logistics center. Coproduction is still the exception rather than the rule in FMS cases, making it difficult to operate on a "business-as-usual" basis.

Frequent face-to-face meetings were held between the Swiss procuring agency, Gruppe fur Ruestungsdiente; the contractor, Northrop; and the USAF to define the scope of the program, schedule, configuration, logistics concept, and to work out the other myriad details required to write a request for quotation. The schedule for writing the request for quotation and its response in the form of a letter of offer and acceptance was critical in that it had to mesh with the Swiss Parliament's cycle of budget considerations.

The pressure of meeting the required deadlines frequently made the workdays long, but it also served as an impetus to get the work done. Under such conditions, errors and oversights are to be expected; however, in the early stages of any program, managers must frequently operate with incomplete information, and must therefore learn to use experience and good judgment to minimize the impact of mistakes.

The Taiwan program was, of necessity, conceived in a different manner. Taiwan had operated F-5As and F-5Bs for a number of years and was familiar with Northrop. In 1972, as one of their 10 National Projects, Taiwan approached Northrop about the possibility of coproducing the F-5E. Northrop conducted an industrial survey outlining requirements for Taiwan's coproduction of the F-5E.

Taiwan elected to sign a direct contract with Northrop. The U.S. Air Force became involved to provide certain equipment common to other of its aircraft, such as central air data computers, generator control units, and engines. These were the same items which the USAF provided to Northrop for other F-5s. The concept was that cost savings could be made by large-quantity buys and standardization in the logistics field. Taiwan recognized this and signed letters of offer for this equipment and USAF management support.

After the signing of the letter of offer, program reviews were used as a formal means of periodic interface by the country, contractor, and the USAF. Taiwan elected to hold the reviews annually. The Swiss initially held quarterly reviews, but changed to a semi-annual basis as the program matured. This difference is probably attributable to the differences between FMS and direct procurement and/or a difference in national temperaments.

When needed, meetings of a lesser scale were held either with the USAF and the contractor, the country and the USAF, or with all three. Minutes of the meetings were formalized by the signatures of the participants.

A solid working relationship between all participants minimized the impact of any surprises resulting from meetings held without USAF participation. Such a working relationship takes time to establish, because mutual respect comes, in part, from dealing with familiar faces. Therefore, frequent changes of personnel should be avoided. It is interesting to note that E. L. Homze, in *Arming the Luftwaffe*, cites frequent personnel changes as a problem with the German procurement system in the 1930s.

In addition to formal program reviews and other less formal meetings, both governments made use of liaison offices in the United States. The Taiwan program had one liaison office at Northrop, manned by a representative of the Aero Industrial Development Center, and another at Headquarters Air Force Logistics Command (AFLC), Wright-Patterson Air Force Base. The latter served as a logistics liaison office but was used by the system program office and the Taiwan Air Force for coordination on logistics aspects involving the SPO. From the time of the initial evaluation effort, the Swiss maintained a liaison office at the system program office manned by representatives of the Swiss procuring agency. Another temporary liaison office was established at Headquarters AFLC. A third office was established at Northrop with representatives from the Swiss procuring agency and the production facility (F+W).

These liaison offices provided a vital link between the USAF and the foreign country. Communications were expedited and the liaison offices augmented the workings of the USAF. In the Swiss case, the liaison office in the system program office provided a daily interface which proved to be of benefit to both the Swiss and the U.S. Air Force. This opportunity for face-to-face communication served to offset complications resulting from restrictive travel.

Management interfaces should be established to meet the situation rather than arbitrary requirements. This is especially important in a coproduction program. The requirements of a coproduction program and a regular foreign military sales program are significantly different and should be recognized as such. The liaison office, while not necessarily innovative, reaffirmed its usefulness as a positive tool in managing these programs.

Face-to-face meetings are expeditious ways to identify problems and formulate mutually agreeable solutions, and should be attended by all organizations involved. While a periodic basis for meetings may be useful, issues should not be placed on a "back burner." A meeting is required when the issues warrant; however, if no issues are perceived and a long period of time has passed, it may be propitious to hold a program review to bring all parties up-to-date.

The location of a meeting is important. At one time, it may be cost-effective to choose a location requiring the least travel by participants. At another time, the agenda may warrant holding the meeting where travel to nearby facilities will provide answers to questions.

Indeed, the location of meetings surfaced a minor problem. If a meeting was held in the United States, the Air Force frequently participated. There was, on the USAF side, some trepidation about meetings between the contractor and the country; fear of agreements reached without USAF knowledge or concurrence was always present.

The contractors, in both the Taiwan and Swiss cases, had direct contracts with the production facilities, and their travel to these facilities was a recognized necessity. Often such visits to the country were expanded to include discussions with the foreign procuring agency, Headquarters Taiwan Air Force, or the Swiss procuring agency. In some cases, USAF personnel in country, the Military Assistance Advisory Group in Taiwan or the air attaché in Switzerland were present. In order for the Air Force to stay abreast of changes, a close, often familiar, relationship between the USAF and the contractor was required. Another periodic requirement was to remind all parties that the USAF had a contract with the procuring agency of the country and a contract with the contractor. The contractor *did not* have a contract with the procuring agency of the country.

Many of the problems brought about by this situation could probably have been alleviated by changes to the cumbersome travel requirements of the USAF.

Funds for USAF travel were included in each letter of offer. Legitimate travel was often hampered by regulations unsuitable to program requirements. The use of a "blanket" country clearance was a great help in reducing the obstacles to travel, especially to Switzerland; unfortunately, blanket clearances are not acceptable to all countries.

Production Responsibilities

Plant operations are managed by the individual production facility. The contractor may be asked to assist by providing advisors to specific functional areas, training in various operations using appropriate tooling, and liaison with the contractor's home plant. The USAF does not have this capability in-house. In the F-5 coproduction cases, this assistance has been handled by direct contracts between Northrop and the individual production facilities.

The letters of offer have committed the USAF to providing the hardware necessary to manufacture the F-5, the logistics support, and the training to make the F-5 operational in-country. A responsibility shared by the USAF and the contractor is that the coproduction line shall meet its scheduled deliveries. The delivery of hardware, both government furnished equipment (GFE) and contractor furnished equipment (CFE), on the agreed upon schedule is the primary means of discharging this responsibility.

Procurement lead time requires additional consideration when establishing schedules. Virtually any item of GFE can be procured as CFE. The trade-off is usually shortened production lead time for a higher cost. In some cases, GFE lead time is 5 months or more than the lead time for the same item procured as CFE. This is due to administrative procedures for consolidating requirements. Estimates of attendant cost can vary greatly.

Lead time is usually adequately considered in the start-up of a coproduction program; however, follow-on programs tend to lessen the importance of lead time. The country will plan the original schedule based on a program go-ahead which is projected into the future so that the lead time is sufficient. Follow-on programs are usually scheduled so as not to have a production break in-country. All of the necessary coordination and authorization processes within the country, plus the U.S. Government requirements for processing a sale, use a goodly amount of procurement lead time. As a result, the first few months of a follow-on program are hand-to-mouth operations.

Contributing to a country's sometimes late initiation of procurement activities is the U.S. admonition not to procure items in anticipation of a sale. The Air Force cannot always maintain a given quantity of necessary government furnished equipment in order to relieve such a situation. That would be a risk inconsistent with the government policy of "not making a profit or taking a loss."

However, there exist several methods of minimizing adverse impacts caused by inadequate lead time. The letter of intent is similar to the letter of offer in that it provides for a customer to make funds available and give necessary direction to procure long-lead items of government furnished equipment. On a direct basis, the contractor uses a similar document to reduce his risk.

The letter of intent requires roughly the same amount of U.S. Government processing time as the letter of offer. If the USAF becomes involved at the time the country requests the letter of offer, the usefulness of a letter of intent is marginal.

Another method is not really a method at all—it is to count on pure luck. The quantity of government furnished equipment on hand at the contractor's facility and available for the production line may be in excess of current needs. This situation arises when GFE is supplied in lot quantities. There may be sufficient time to use these items to support coproduction requirements until assets actually procured for the coproduction program become available for payback. This may be considered if the inventory control technique does not have to meet limitations imposed by segregation of assets by program. A system of first-in, first-out or last-in, first-out can accommodate such a payback method.

This last method is feasible only if large quantity aircraft programs with long production runs and similar configurations are in-being when the follow-on program is initiated. Other consideration must be taken for higher priority programs in-being. As stated at the outset, this method is purely a function of luck-of-the-draw and should not be considered reliable.

Equipment installed in coproduction aircraft receives considerably more handling, and is therefore subject to a greater possibility of damage. Government furnished equipment in the case of the F-5 is delivered to the contractor, who performs appropriate receiving inspections and repairs an item if necessary. The item is then packaged for shipment to the coproduction facility.

At the coproduction facility, the item undergoes another inspection based on the same work order used by the contractor. If the item does not pass this inspection, a problem may arise. Usually, a coproduction facility does not have the capability to repair an item, and it does not have the vendor support which is readily available to the contractor. This problem must be recognized and a remedy proposed during the initial planning of the coproduction program. This planning must provide for the coproduction line to stay in operation in the event of such an occurrence.

For a while, when Northrop had high F-5 production runs to satisfy many customers, the Taiwan coproduction line was treated as another part of the Northrop production line, tied to it by a rather long umbilical cord. If an item was not serviceable in Taiwan, it was returned to Northrop and a replacement, if

available, was shipped immediately. Taiwan picked up the added expense and the system worked well. This system was unique to this situation and was not within any USAF repair or return procedure. Its effectiveness hinged on there being more assets available than were required at any specific moment on the Northrop production line. The equipment delivery rates were higher than aircraft production rates. The larger the ongoing production program at Northrop, the longer the time span between the delivery of the last item of GFE and the delivery of the last aircraft.

When deliveries had been made to the large-quantity buyers of F-5s, new buyers were interested in programs with fewer aircraft. The ensuing shorter production runs dictated that the Taiwan procedure not be continued. This came as no surprise, since indications of the impending changes in procedure had been present for the preceding 2 years.

The solution was obvious—Taiwan's logistics service had to become involved. In all fairness it must be said that at the beginning of the coproduction program, Taiwan's logistics service could not support operational units, let alone the coproduction line. However, it rallied from ground zero to a position where it could consistently maintain the F-5E at a higher state of operational readiness than could the USAF.

The support of the coproduction line by Northrop was an interim procedure that took care of the coproduction program until the logistics service could support it. Although reduced support from the contractor coincided with the Taiwan logistics service's increased capability, Taiwan resisted the curtailment of direct Northrop support for internal reasons. The USAF gave its advice and recommended procedures for handling the problem. Since it was recognized that this was a Taiwan problem that demanded a Taiwan solution, the distasteful but necessary steps were taken to terminate the interim procedure.

The Taiwan and Swiss cases offer contrasting approaches to the same problem. In Taiwan, the logistics service is patterned after, and tied to, the U.S. Air Force Logistics Command by way of Supply Support Arrangement (SSA). Within the terms of this SSA, Taiwan may requisition items for AFLC stocks, and return items for repair or credit. A similar procedure was established between Taiwan's coproduction facility and their logistics service.

On the other hand, the Swiss neutrality required that they be entirely self-sufficient. To this end, the Swiss established full depot-level repair capability for their F-5s. This gave the coproduction facility the necessary support to keep the production line going.

If an interim procedure is necessary, it should have a termination date established at the outset. At each program review or at another appropriate time, there should be a report on the progress of the logistics service in assuming production support. Although it is difficult to terminate any system that appears to

be working, one must resist the temptation to maintain an interim procedure any longer than circumstances demand.

The replacement of an unserviceable item to keep the production line moving is one issue, as is the corollary: What to do with the item that has failed? Various procedures for handling these items are spelled out in numerous regulations. All too frequently, the guidance provided by one regulation conflicts with that given in another. It is foolish to assume that a foreign country can deal with this confusion when, in fact, various USAF organizations cannot. This is a Gordian Knot which has yet to feel the cutting edge of proper staff attention.

Configuration

After a particular model of aircraft, such as the F-5E, has been selected, a country may choose to optimize or fine-tune its capabiities to meet special theater conditions. It is important to remember that the cost difference between a "vanilla," or basic configuration, and a more specialized version is not solely a function of the recurring cost of the additional hardware.

Let's look at this problem more closely. The system program office and the contractor advise the country of available options and provide a rough estimate of the costs associated with each. The country must then rationalize these costs versus required capability to determine the final configuration. In the case of the F-5, some of these options are an inertial navigation system, VHF radio, instrument landing system, Maverick missiles, laser target designators, aerial refueling, and anti-skid brakes.

Peculiar country requirements may induce that country to approach vendors directly. The equipment may eventually be supplied by the contractor or as country-government furnished equipment. This in itself offers no major problem. But when the country interjects itelf in technical discussions, full coordination of the country, contractor, vendor, and the USAF becomes tenuous.

For example, the country itself may choose to integrate the equipment and the aircraft, which is inconsistent with the normal practice of having one organization, usually the contractor, responsible for integration. On assuming this responsibility, the country must be made to understand that if the equipment does not "play" when installed in the aircraft, then they themselves will have to analyze the problem, design the fix, and incorporate it. This is no small task.

A real problem arises if the vendor quotes a price to the country and the contractor. When the contractor adds to that figure his wrap-around costs and negotiates with the USAF, the country wants an explanation as to the difference in costs, even when the adjusted overall costs remain well within the budget figure. It can take considerable time and effort to respond to such inquiries, and sometimes slows work being done on other parts of the program.

No easy answer is available. One can take the time and effort to respond, while reminding the country that other work is being slowed. At times, this approach works to cause a healthy review of the problem. Another course is to ignore the request, but this may cause undue friction. If time and resources are available, one should take the former approach; if not, the second approach may be pursued, but with a velvet-glove touch.

In a coproduction program, the cost of additional tooling, labor, and material must also be considered when analyzing overall program costs, Some options may not affect the work being done in-country, depending on how the coproduction program is structured. Consideration should be given to the possibility that future changes in the configuration may require changes in tooling and additional training. However, there is no accurate method of estimating either the cost or the probability of such changes on a long-term basis. Sometimes, maturity of the design can be a measure of help.

A coproduction capability offers a country the potential to make extensive modifications or retrofits of new equipment. This potential varies directly with the capability of the coproduction facility to manufacture the aircraft. Taiwan has produced over 140 F-5Es, and has orders for nearly 100 more . In the beginning, Taiwan elected to keep their configuration closely aligned with the basic configuration F-5E. At present, they are adding extensive capability to their new F-5Es. In addition, Taiwan will be modifying existing aircraft to the new configuration. In only one other instance has such an extensive modification been attempted with the F-5, and it required moving the aircraft back to Northrop Corporation for the modification.

The difficulty of predicting coproduction program costs and benefits is no small matter. Unforseen events occur. The longer the production run, the greater the risks. However, a coproduction capability does increase a country's options in how to react. Such a capability can be either an asset or a liability, depending upon the course of action the country chooses.

Contracts

The Taiwan and Switzerland programs were similar in that the USAF had separate contracts for each. Normally, one contract is negotiated for an annual buy of aircraft which will be delivered to several countries. In the Taiwan case, a separate contract was necessary because aircraft were not being provided. However, it was used to provide a method of incorporating engineering changes and receiving, testing, and packing government furnished aeronautical equipment for shipment to Taiwan. Using somewhat the same rationale, the Swiss program had a separate contract for two reasons, unfinished aircraft were being delivered, and the Swiss required it.

Contracts which separated these programs from others were logical in that many line items on the coproduction program contract would not be found on a contract which is used to provide complete, fly-away aircraft. However, it must be cautioned that this separation could easily become isolation. There are several items which are subject to annual negotiation, such as overhead rates, technical order maintenance, and provisioning, documentation and effort. The possibilities exist of either nonapportioning or of misapportioning these costs over all contracts. In addition, in the case of Taiwan, the FMS contract must be integrated with the direct contract to preclude later "but-I-thought-you-had-it" contentions.

Such errors of omission or commission may be minimized by close coordination of the contracting and financial (pricing) functions by both the system program office and the contractor. Consideration should also be given to using the USAF-contractor contract as a means of coordinating the FMS and direct contracts, thereby providing positive control.

It is understandable that any such USAF control may be considered an invasion of the contractor's right to contract. Such control would not be for the purpose of determining how effective the contractor is at negotiation; rather, it would serve to establish responsibility for charging costs which are required by regulation. As a fallout, it would also indicate whether the USAF was being overcharged for certain costs on other contracts. Experience shows that this visibility into the direct contract should not be rejected out of hand.

Offset

An increasingly important aspect of the "make-or-buy" decision is the opportunity to offset the program cost. An offset arrangement may be a government-to-government arrangement or may be a direct agreement between the purchaser and the contractor. In addition, the offset may or may not be concerned with the coproduction program itself.

Offset programs are more politically charged than the basic coproduction program. As a rationale for the coproduction program, an offset program is touted as a means to reduce overall costs.

An offset program must be well defined and documented in terms of cost, schedule, and performance, or goal. In a government-to-government arrangement, both parties must recognize that USAF regulations prohibit the USAF from making a profit or taking a loss. By stretching this concept, it becomes evident that the costs associated with administering any offset agreement must be borne by the customer. In the case of a contractor-to-purchaser agreement, prudent business practice may necessitate a lower profit rate to cover administrative costs. However, profits may actually increase due to the larger basis of profit.

The Air Force has avoided any form of offset agreement that would imply that the contractor is directed to use parts or assemblies from a coproduction facility. There are several reasons for this. The USAF would not be acting in its best interests by interfering in the contractor's "make-or-buy" decisions and vendor contract awards. The cost of requiring the use of coproduced assemblies would not be an accurate reflection of the marketplace.

Another reason for USAF non-involvement has to do with quality assurance; it is not manned to administer a quality assurance program in a coproduction facility. If the contractor refuses to accept coproduced assemblies because of poor quality, then the USAF must become involved which is necessarily cumbersome due to the three-sided interface. This problem becomes less noticeable to the USAF if the contractor works his own offset arrangement with the coproduction facility.

Agreement must be reached on some form of schedule. A period of performance such as 1 year may be used. In a government-to-government arrangement, this period should not ignore the life-span of the contract with the contractor.

If a production contract is amended to cover the costs of administering an offset, the schedule for delivery of hardware should be similar to the period of performance required by the offset. If it is not, final closure of a contract is delayed, and a final settlement is not timely. If the contractor has, in fact, been overpaid he has the use of funds to which he is not entitled, and derives benefits from investments made with those funds.

The U.S. Government has limited means for implementing an offset. The cooperation of the contractor is secured by using the production contract as a means of recognizing his costs for implementing the offset. This is especially important if the offset is not necessarily concerned with the coproduction program. An example would be the Swiss case when the U.S. Government agreed to provide competitive opportunities for Swiss industry or, in effect, to increase the sales of Swiss industry by a set percentage of the letter of offer value. The contractors, Northrop and General Electric (for the J-85 engines), had the marketing machinery to expose Swiss industry to more U.S. opportunities.

As a counterpoint, the Taiwan case was a purchaser-to-contractor agreement, the USAF being involved in only a minor role. Taiwan's offset is directly involved with the coproduction program in that Taiwan manufactures assemblies for use on Northrop's production line. In effect, the Aero Industrial Development Center at Taichung is a vendor to Northrop. The U.S. Air Force becomes involved only to the extent that it does with other vendors, i.e., quality assurance.

The definition of the desired goal is a basic requirement of any endeavor, and the offset endeavor is no different. There must be a point in time when both parties may acknowledge that what they asked and paid for has been delivered. As in

the Swiss case, the goal may be additional business of a specified value, such as a specific percentage of the letter of offer value.

Compare this to a situation in which a purchaser is offered an opportunity to build a given percentage of an aircraft as a vendor. Several questions arise: How does one measure the cost of an aircraft? By the cost of material or labor? By purchaser or contractor cost? Is allowance made for different labor rates or material costs? This same issue may be germane to the original coproduction decision. Unwary parties may make statements that critics can use to raise doubts about the wisdom of such arrangements.

Conclusion

Summarizing past experience to form general statements can be misleading. The basis of this article has been experiences with the F-5E programs in Taiwan and Switzerland; generalizing those experiences into profound statements concerning all coproduction programs is unwarranted because, simply, this data base is too limited and these programs are too unique.

With this in mind, we can state that coproduction programs are different; however, they are not so different as to require the complete overhaul of existing procedures. Some changes or clarifications are required regarding the return of discrepant materials. The current regulations governing foreign travel are, by and large, a hindrance and make no noticeable contribution to the effective use of resources.

The benefits to a country which coproduces aircraft must be evaluated by assessing that country's interests and requirements. Likewise, though they are usually measured in absolute terms, the costs of a coproduction program must take into account probable advantages as well as possible disadvantages. ‖

Army/Navy Guided Projectiles: A Joint Program that Works

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Captain J. D. Miceli, USN

Both the Army and the Navy are deeply involved with developments that will lead to the availability of guided projectiles launched from existing field artillery and fleet gun weapon systems. The projectiles will provide deadly accuracy from stand-off engagement ranges enabling, for the first time in the history of gunnery, the potential for effective first-round engagement of fixed and moving hard-point targets such as tanks, bunkers, and high-speed patrol craft. These new developments offer not only dramatic increases in the potential lethality of existing gun and howitzer systems, but also the potential for substantial reductions in ammunition expenditure and associated logistics support.

The original concept for a guided projectile was initiated at the Naval Surface Weapons Center, Dahlgren Laboratory, Dahlgren, Virginia. In 1969 the Navy and Marine Corps participated directly, accompanied by substantial Army interest. These early developments utilized technology from the battle-proven Paveway guided glide bomb, and were first tested in 8-inch configuration fired from 8-inch Army/USMC howitzers.

Working together, existing Army and Navy staffs prepared the necessary documentation and presentational material to obtain successful Defense Systems Acquisition Review Council (DSARC) review release of the Army's Copperhead cannon-launched guided projectile to producibility engineering planning, and release of the Navy 5-inch and 8-inch semi-active laser guided projectiles to engineering development. In near record time, the joint project office, utilizing Army research and development command personnel who had established the Copperhead engineering development contract, awarded contracts to Martin Marietta for development of first the 5-inch and then the 8-inch Navy versions. The Navy was authorized to continue independently in advanced development of the anti-aircraft, infrared seeker for use with the 5-inch and 8-inch guided projectile bodies, and in integration and at-sea testing of overall fleet guided projectile weapon systems.

It is evident that the joint project office was established *in medias res*, after years of defense of their vital interest by the individual services involved, an environment hardly conducive to the immediate and continuing success experienced by the joint project. Success of the effort must be attributed to the character and quality of leadership afforded this joint effort by both the Army and the Navy. Specific consideration must be afforded the role of the joint-project manager. Consider the problems of rapidly integrating two additional high technology projects into a successful but challenging ongoing project while simultaneously:

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building up a new staff; orienting and training personnel from another service in Army procedures and protocol; overcoming residual vestiges of 4 years of fierce interservice competition; maintaining communications with and accommodating higher authority in another service; identifying and establishing procedures for effective utilization of laboratories and field activities of another service; assimilating varying operating requirements, design approaches, and technology; accommodating the unique system integration and operational test and evaluation requirements of another service; and establishing an effective overall team effort ensuring synergistic mutual support and highly effective promulgation of all projects. The success of this effort is attested to by the Assistant Secretary of the Army for Research, Development and Acquisition, the Honorable Percy A. Pierre, in testimony before the Congress: "This program, in the way we have set it up as an interservice program, managed by the services, has served as a model for...other programs in DOD, and the particular structure that we've used has worked well."

Both Services Benefit

Formation of the joint project has been of substantial value to the two services. Benefits accruing to the Navy as a result of the Army's experience and lessons learned in Copperhead development are as follows:

- Use of test facilities at the White Sands Missile Range;
- Utilization of Army cost/schedule control systems criteria specialists in validation of the contractor's program management;
- Utilization of Army-proven design and hardware in the Navy round (including state-of-the-art large-scale integrated circuits);
- Utilization of the Army's six-degrees of freedom simulation techniques;
- Utilization of Army test results to ensure performance of the Navy design.

Direct benefits accruing to the Army include:

- Utilization of experienced Navy field activities for validation of technical data packages (Naval Avionics Center);
- Utilization of the Naval Material Command's expertise in reliability and quality assurance;
- Utilization of the Navy-developed titanium gyroscope.

Despite the relative maturity of both the Army and Navy designs at the time the joint project was formed, the joint project has successfully developed 29 peculiar hardware parts common to both projectiles, with savings in direct development costs of nearly $2 million. While indirect savings attributed to use of a common technology base in both rounds are difficult to quantify, the best available estimate of such savings is in the $1.0-$1.4 million range.

The Army and Navy have been able to take full advantage of the data, experience, and expertise available from each other. They are collaborating in the development of an approach to implementation of second source to attain maximum competitive leverage in production negotiations for all guided projectiles.

The joint project is still a young organization, just 2 years old. It is still learning and evolving; however, it has been in existence long enough to prove that such an organization, under strong leadership, can be mutually beneficial to the services involved, offering a broad range of opportunity for cost savings to each.

Lessons Learned

A number of lessons learned have resulted from this effort:

- The earlier in concept formulation/development that a joint charter can be established, the greater the leverage toward achievement of ultimate commonality.
- The need for strong, flexible leadership cannot be overemphasized.
- Establishment of equitable procedures is critical to the ultimate success of any joint venture. For example, in the joint Army/Navy guided projectile project office, development of the Navy round is directed by the senior Navy representative, who is also deputy to the project manager. Development of the Army round is directed by an Army officer reporting to the joint (Army) project manager. The senior service representative prepares the fitness/evaluation reports of personnel of his own service participating in the joint project. Each service directs its own weapon system integration efforts and conducts its own operational test and evaluation, ensuring suitability of the jointly developed product with respect to the requirements of the individual services.
- Allowance must be made for the enormous number of differences in procedures and approaches among the services. Completely different directives and instructions govern the two services. What the Army calls "operational test phase II" is what the Navy calls "operational test phase III," leading to one of many annoying "language" barriers. Army project office organizations tend to be large and pay their own salaries, whereas Navy project organizations tend to be quite small (supported more heavily by field activities and command matrix organizations) and are provided at no personnel cost to the project. Army test ranges tend to be independently funded, charging very little for project use, whereas Navy test facilities tend to be fully charged directly to the projects using them.
- Allowance must be made for the fact that, in a multi-service project, continuing interest among higher authority in each service will result in a legitimate requirement for additional briefings and communications. On the other hand, much of the same briefing material and correspondence will satisfy both.

- As a corollary to the difference in funding project office personnel, it is interesting to note that the Navy has experienced particular difficulty in staffing the joint project. The Navy billets count against headquarters command ceiling points at a time when ceilings are being reduced and classifications frozen. In consonance with Army organizational patterns, the Navy has attempted to provide a joint project office contingent that would be almost three times the size of the original Navy project management group while maintaining the in-house Navy group for development of the infrared seeker, for weapon systems integration, and for test and evaluation coordination. Similar difficulties may be expected for any participating service involved in staffing a joint project at a location remote to the participating service's own project management sites.
- Increased travel burdens will also be incurred by key personnel of the participating service in fulfilling necessary coordination and communication requirements of the parent service.
- The authority and independence of a joint project can be used to advantage by both services to expedite and assure both joint and individual development goals. Joint responsibilities can provide an effective motivational force on individual service staffs to ensure expeditious response to particular problems.
- The very nature of joint participation offers increased opportunity to the individual services to utilize a fresh outlook, varied procedures, and a wealth of differing backgrounds and different points of view to improve and implement overall project management functions.

Summary

In summary, effective joint project management is a challenge to all participants—one which can be mutually advantageous, offering great potential rewards to the individual service. From the point of view of the individual project manager, moreover, there is probably no other single opportunity in management which can, with such speed and effectiveness, provide individual growth and development of technical, managerial, and political proficiency. When equitably established, the joint organization can offer increased opportunity for exposure and growth. Under unrelenting budget pressure, the services may be expected to increase the utilization of the attractive joint-project approach to further their technological development with increasingly limited individual resources.

Augustine's Laws and Major System Development Programs

50

Norman R. Augustine

Insight into the problems of program management is sometimes found in unexpected places. For example, A. A. Milne could well have been writing about the sufferings of managers of large system development activities in the opening paragraph of *Winnie-the-Pooh*. "Here is Edward Bear," he wrote, "coming downstairs now, bump, bump, bump, on the back of his head, behind Christopher Robin. It is, as far as he knows, the only way of coming downstairs, but sometimes he feels that there really is another way...if only he could stop bumping for a moment and think of it!"

Indeed, there *is* a better way, as innumerable highly successful programs have demonstrated. Still, there remains that large set of much maligned projects which, were they ever to be documented into a movie, might best be viewed with the film run backward in order to ensure a happy ending. It is largely from these programs that Augustine's Laws have been formulated. The laws are dedicated to the proposition that with a better understanding of the history of past programs, one need only selectively repeat history in the future. Further, it is suggested that the behavior of large system management activities is as amenable to analysis as are most of the systems themselves. Each of the 15 laws, with a sample of the evidence supporting its existence, is examined in the following paragraphs.

Employer of Only Resort

Law Number I corroborates the late Senator Everett Dirksen's observation about big government: "A billion here, and a billion there," he stated, "and pretty soon it adds up to real money."

The percentage of civilian workers in the United States employed by government at the Federal, State and local levels is displayed in Figure 1. A growth trend is observed which has been very predictable and monotonic throughout the history of the nation. A modest extrapolation into the future, shown by the dotted portion of the trend line, indicates that the time is not too distant when one

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Author's Note: "Augustine's Laws" are intended to help explain the tribulations of program management. They have been formulated over a period of years and are based on observations of a large number of actual development programs. Although some of the laws have been published previously, this is the first time that all 15 laws have been collected as an entity.

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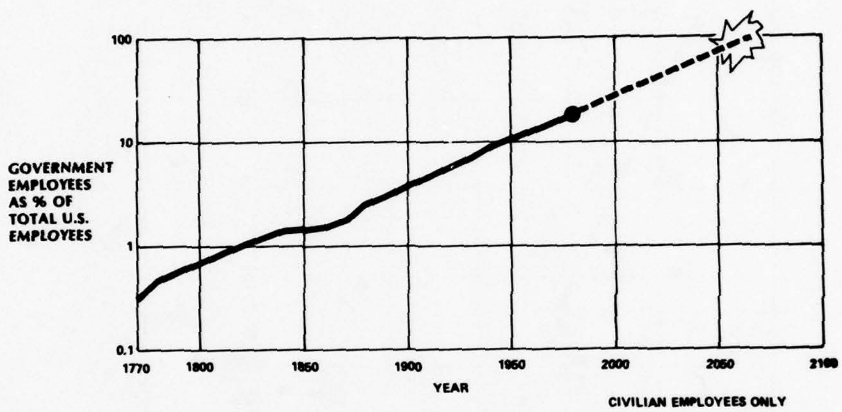
FIGURE 1
Growth of Government



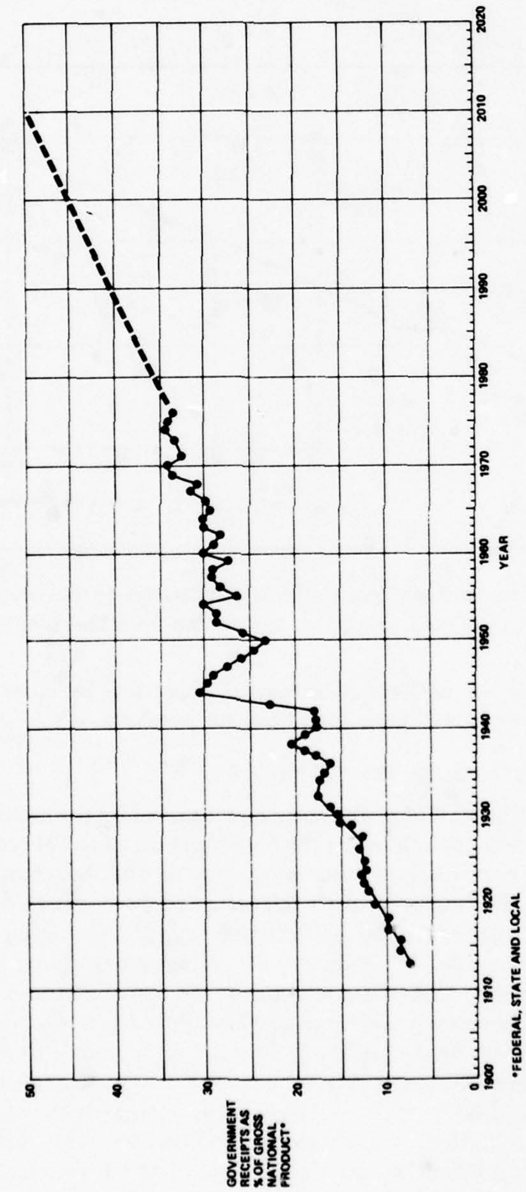
should expect 100 percent of the working population to be working for the government. Taking the next logical step, one can then state Augustine's First Law:

I: By the time of the nation's tricentennial, there will be more government workers in the United States than there are workers.

For What It's Worth, Save Your Money

This trend in the growth of government as measured by the number of people it employs is, of course, paralleled by the government's financial receipts; and in turn by the government's ability even to conduct its own programs on its own behalf as it sees fit. For example, there is now a tax collector somewhere in the U.S. extracting a dollar every 25 milliseconds—including roughly half of each dollar of the profits earned by industry. By extrapolating the trend shown in Figure 2, it can be seen that the government will have all the money that is generated in the U.S. economy by the year 2120 and, as has already been noted, it will directly employ all the people about 60 years prior to that time. What happens during the interim period between these dates is not yet clear, but poses the interesting question of whether the last person left in the private sector will have to support the entire nation's work force, or whether he or she instead will individually enjoy the full benefit of those residual funds not yet controlled by the

FIGURE 2
The Demise of Free Enterprise



government. Whatever the explanation, this uncertainty leads to the guarded optimism expressed in Law Number II, actually the corollary to the first law, which is:

II: People working in the private sector should try to save money if at all feasible. There remains a possibility that it may someday be valuable again.

In terms of the fraction of the gross national product absorbed in the form of government receipts, one can also use the extrapolation presented in Figure 2 to ascertain that the U.S. lags England by only 17 years and Sweden by only 56 years in this respect.

The significance of these observations to an industrial program manager is obvious. Their significance to a government program manager, although perhaps less obvious, is nonetheless every bit as significant; namely, competition among potential sources is the essence of a program manager's leverage, and the absence of a multiplicity of strong competitors can only lessen the government program manager's chances of success.

On Striving to Be Average

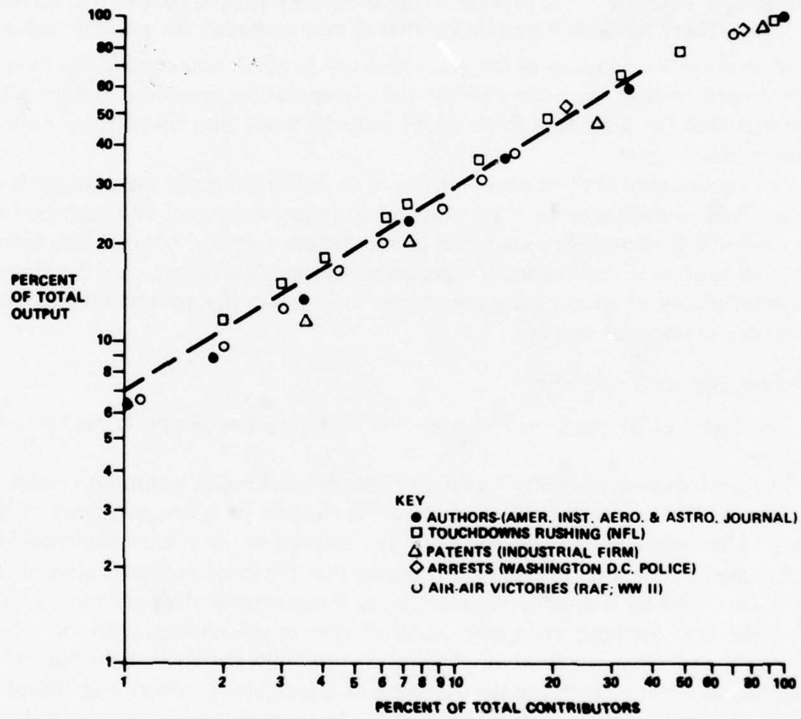
Law Number III confirms the suspicion that *very few people come up to the average.*

The contribution made by a group of people working in a common endeavor tends to be highly concentrated in the achievements of a few members of that group. The degree of this concentration is observed to obey a fundamental law, as indicated by the data in Figure 3. It is seen that the great predominance of output is produced by a disproportionately small segment of the participants, with the same law seeming to apply whether one is addressing authors, pilots, engineers, policemen, or football players. As one "digs deeper into the barrel," so to speak, in order to increase the manning of a given task, the average output is merely driven downward and, ultimately, large numbers of participants are added with hardly any increase in productivity at all (unless, of course, changes in work methods are also introduced). Conversely, substantial reductions in manning—eliminating the least productive contributors—can be made with little impact on overall output. In fact, the least productive half of all participants seems to generate *no more* than 20 percent of the total output.

It might be more accurate to describe the above observation as merely a generalization or corollary of V. Pareto's work published in 1897, in which it was demonstrated that the proportion of people with an income N was proportional to $1/N^{1.5}$.

The results presented in Figure 3 are probably understated, since the data base considers only participants who made at least *some* contribution, such as obtaining one patent, when in reality there are many who obtained *no* patents. Further,

FIGURE 3
Concentration of Productivity



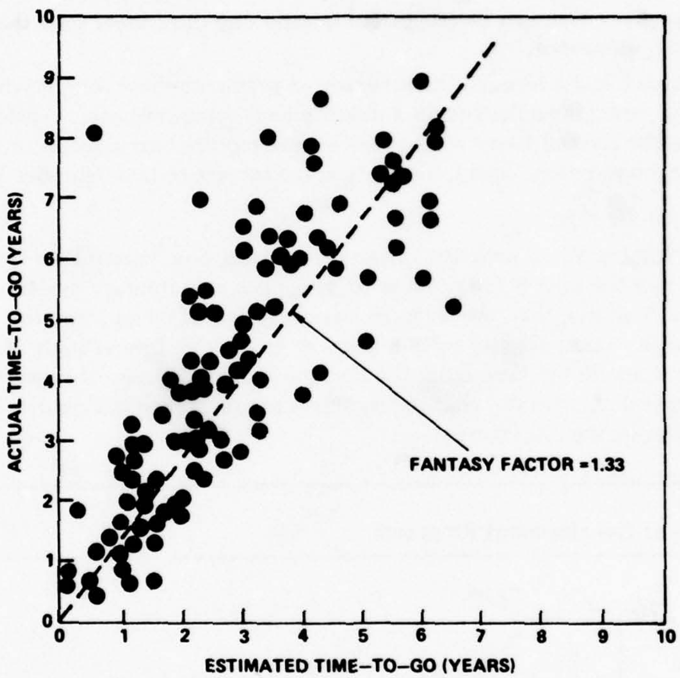
there are unquestionably those who produce negative output, such as the worker who makes so many mistakes that a great deal of the time of other potentially productive workers is consumed in rectifying the problems the former has created. Only about one-third of the workers typically achieve a level of contribution equal to the average of all those who contribute.

This leads to the third law, which relates to the allocation of manpower and can be stated as follows:

III: One-tenth of the people involved in a given endeavor produce at least one-third of the output, and increasing the number of participants merely serves to reduce the average performance.

As has often been pointed out, when an individual item can only be produced at a financial loss, it is very, very difficult to make it up on volume.

FIGURE 4
Accuracy of Projecting Accomplishment Date for Major Milestones



The Reality of the Fantasy Factor

Law Number IV explains why one should never commit to complete a task within 6 months of the end of any fiscal year—in either direction.

In 1798, Eli Whitney contracted to deliver 10,000 muskets to the Continental Army within 28 months. As things worked out, he delivered them in 37 months, or in about one-third more time than had been anticipated.

During 1978, a number of new systems were delivered to the U.S. military forces by major defense contractors. On the average, according to the reports submitted to the Congress, these systems were delivered in about one-third more time than had been anticipated.

The fraction "one-third" seems to have scientific significance in determining the schedule error associated with predicting major program events (some say the correct number is actually more nearly equal to one over *pi*). The data shown in Figure 4 are derived from a large number of official schedule estimates predicting

when various milestones, such as first flight, first delivery, etc., will occur. These data, in turn, form the basis for Law Number IV, which defines the concept of the Fantasy Factor:

IV: Any given task can be completed in only one-third more time than is currently estimated.

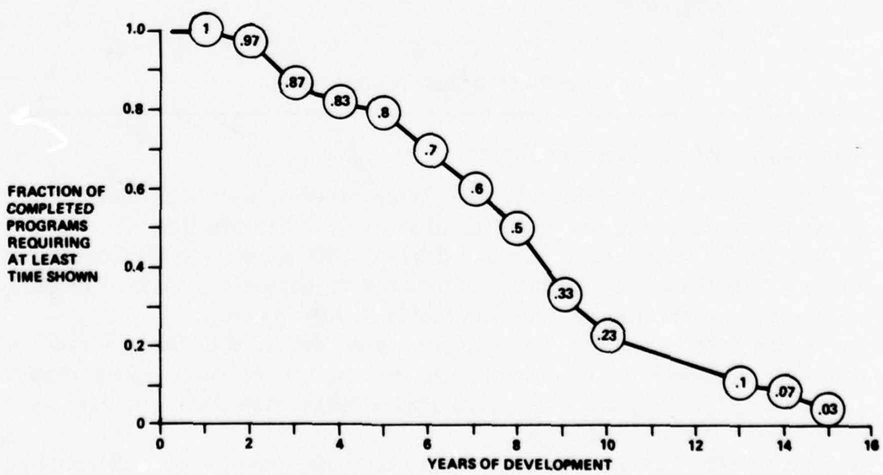
The above law addresses the accuracy of predicting how long it will take to reach any particular milestone in a development program's life. A different law addresses the overall trend of increasing time required actually to prosecute a development program. This latter issue is the subject of Law Number V.

So Old for Its Age

Law Number V, on program geriatrics, explains how World War II was won in about half the time it today takes to develop a new military system.

Figure 5 shows that the average major system development for national defense today takes slightly over 8 years to complete. Interestingly, the *doing* time, for example the time from the beginning of the design of a new airplane until its first flight, has not changed significantly during the last quarter of a century, as can be seen in *Figure 6*.

FIGURE 5
Duration of Development Programs



What *has* changed is the decision/approval time it takes to get a new program started, together with the time it takes to get it fielded once the development has been completed. The historical ratio of *planning* time to *doing* time for a number of major system developments is shown in Figure 7. On the average, the total time it takes to develop a new system, including decision and approval time, has been increasing at a rate of 3 months per year, each year, for the past 15 years.

Law Number V can then be stated, based in part on the fact that the half-life of most technologies has been determined elsewhere to be on the order of 10 years:

V: If current trends persist, most new systems will be obsolete only slightly before they are born.

Work and the Theory of Relativity

Law Number VI offers an alternative to the bus company serving the Bagnall to Greenfields route in England, whose spokesman recently countered criticism that half-empty buses were speeding past long queues of would-be riders with the explanation, "It is impossible for the drivers to keep their timetable if they have to stop for passengers."

In competitive, time-sensitive markets, managers are simultaneously challenged on three fronts. Not only must they produce a desirable product at a reasonable price, but in addition they must deliver their output to the

FIGURE 6
Trends in Development Time

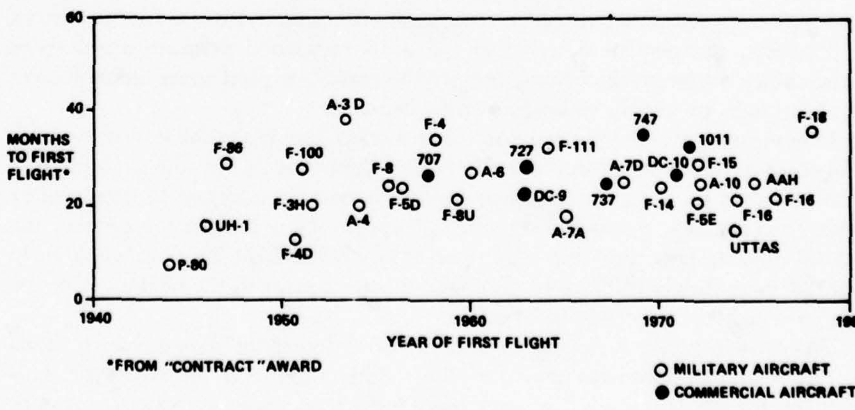
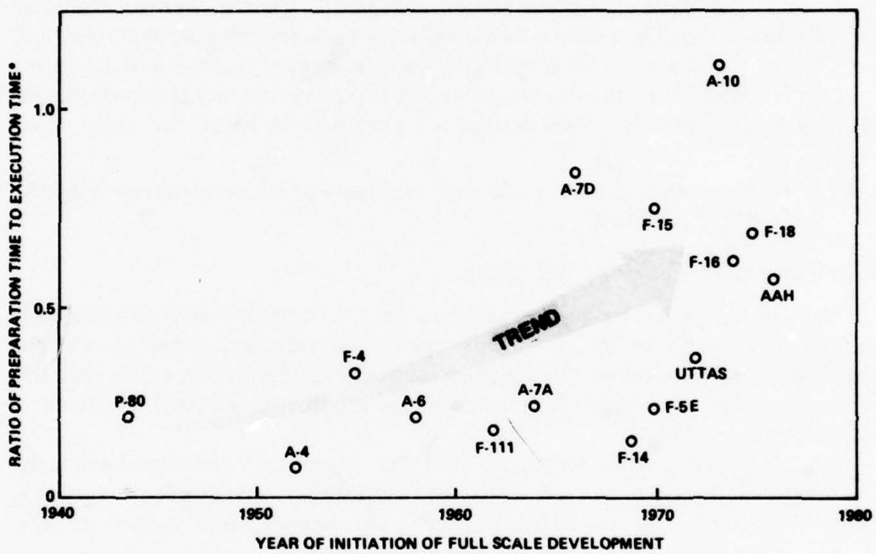


FIGURE 7

Relationship of "Decision" Time to "Doing" Time



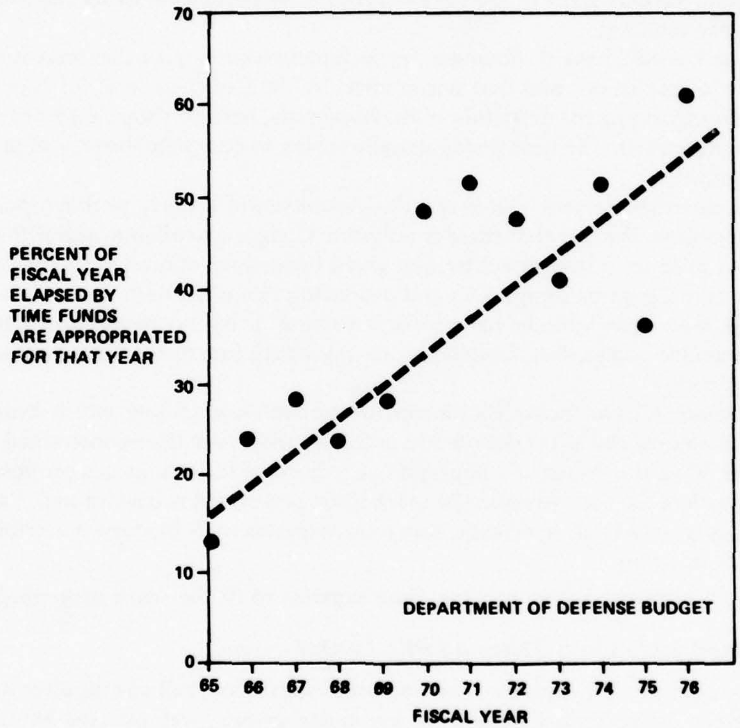
*DEFINED AS (TIME FROM CONCEPT FORMULATION TO START OF FULL SCALE DEVELOPMENT) DIVIDED BY (TIME FROM START OF FULL SCALE DEVELOPMENT TO INITIAL OPERATIONAL CAPABILITY)

marketplace in a timely manner. This urgency is characteristic of a large variety of products, irrespective of whether the aforementioned pressure arises from perishability of the product itself, the need to rapidly exploit some technological breakthrough, or merely to keep up with demand.

In environments wherein only one source of an item is available, however, an altogether different set of dynamics prevails. Consider, as but one example, the problem faced by the U.S. Congress as it each year, in addition to a myriad of other crucial tasks, pursues the matter of approving a budget for each of the Federal departments. For one reason or another, the Congress has apparently found it increasingly difficult to complete this task prior to the beginning of the year in which the money is to be spent.

The data in Figure 8 display how in each fiscal year the date at which funds are finally appropriated has tended to slide further and further into the year. This problem recently culminated, in the case of the defense budget, in a circumstance wherein the appropriation act did not become law until the year was more than

FIGURE 8
Increasing Length of Budget Approval Process



half completed! The challenge posed to those charged with executing that budget can, in fact, be accurately imagined...particularly those unfortunate managers whose requested budget was halved.

What the future portended for those same managers could be glimpsed by projecting forward in time the trend line in Figure 8. The inevitable conclusion seemed to be that it would be only about a decade until the situation reached crisis proportions; i.e., the budget would not be approved until the year was altogether past.

Fully recognizing this dilemma, the Congress proceeded to rectify the intensifying problem with both alacrity and decisiveness. Less imaginative managers in

private industry, given the same circumstances, might have resorted to such conventional techniques as eliminating some of the 18 votes taken each year on large segments of the budget, or even to a process of expediting the budget cycle by combining various steps in the review process, or perhaps even by resorting to multi-year funding.

As luck would have it, however, no such pedestrian approaches were needed. The obvious solution, and that seized upon by the Congress, was, of course, to pass a law changing the definition of the fiscal year, hereafter slipping it neatly into compliance with the time it was actually taking to complete the task of preparing a budget.

The essential element that made this resolution of a nasty problem possible was, of course, the fact that there is only one Congress available, and if this one does not produce a budget act by any given time, there is no danger of another competitive Congress stepping in and producing one of its own. It can be safely inferred that such latitude for problem solving is by no means restricted to governmental bodies, but is attendant to any entity functioning in a sole-source environment.

Professor C. Northcote Parkinson, in the well-known law which bears his name, examined the effort devoted to activities which are time-constrained. Law Number VI of the present monograph is a reciprocal to Parkinson's proposition, and considers the case wherein the *work* to be performed is constrained. Parkinson's Law pointed out, in essence, that work expands to fit the time prescribed. In contradistinction:

VI: In a noncompetitive process, time expands to fit the work prescribed.

The Impossible Only Takes a Little Longer

Law Number VII explains why one professional football coach, after having been given an unlimited budget by the club's owner, was accused before the season had begun of having overspent it.

Two types of uncertainty plague most major programs: known-unknowns and unknown-unknowns. The known-unknowns, such as the composition of the moon's surface at the exact location of the first Apollo landing, can be accommodated and a program planned which hedges against their consequences. The second category, the unknown-unknowns, cannot be specifically identified in advance, but their existence can be predicted with every bit as much confidence as insurance companies place in actuarial statistics. An example of the latter category of unknown is the lightning that struck Apollo XII shortly after its launch on the way to the moon.

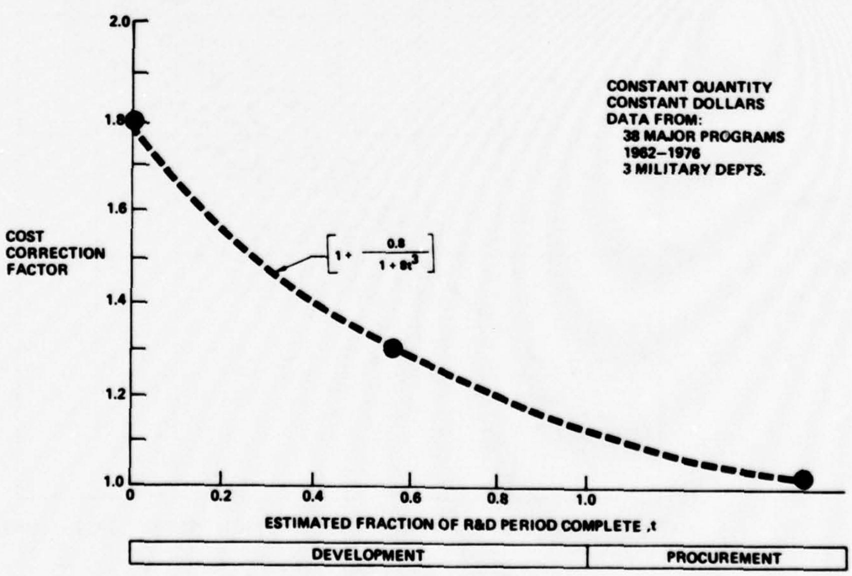
Somehow, in every major program, "lightning" strikes *somewhere*. It cannot be predicted *where* it will strike, only that it *will* strike. But, unfortunately, the

budgeting system used in defense planning has not, at least until recently, permitted the recognition of such contingencies or the provision of lightning rods. This was in part due to the vulnerability of so-called management reserves to congressional budget cutting, and partly due to optimistic bids engendered in a cost-reimbursable competitive contract award environment.

Although there are available many more sophisticated ways of predicting program costs were one in fact to *use* them, the cost-estimating correction factor presented in Figure 9 would, in the aggregate, have eliminated overruns on defense programs during the recent decade had it been available and applied. It should be noted that when Figure 9 is in fact applied, the decision maker will undoubtedly have been misinformed as to what fraction of the program is actually complete. This distortion has already been compensated for in Figure 9 using Law Number IV.

A word of caution is, of course, in order with respect to the delegation of authority for the management of the contingency funds thus determined, lest

FIGURE 9
Predicting Program Cost (R&D Plus Procurement)



Parkinson's Law exert itself and costs thereby rise to meet the accessible funds. Thus we have:

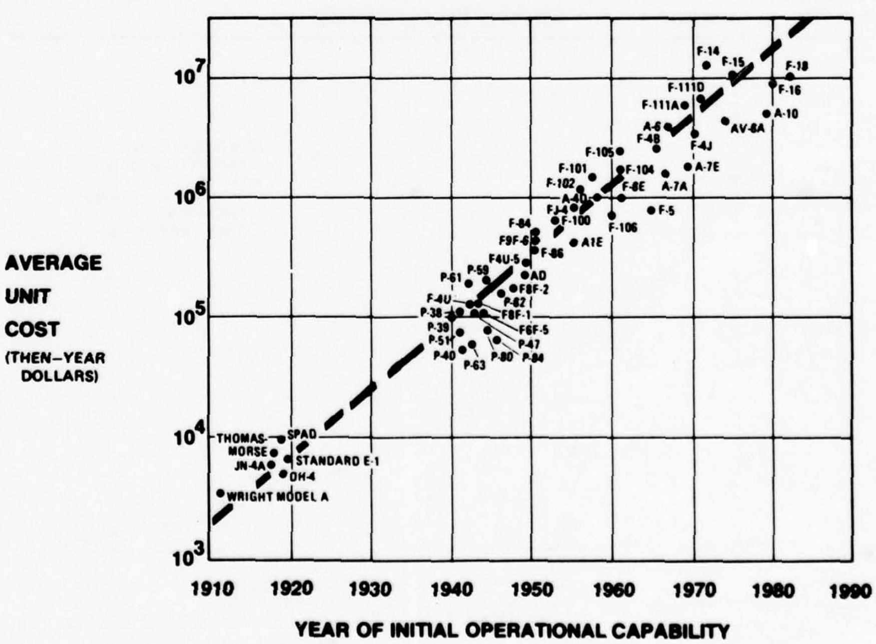
VII: In order to better the record of some program cost estimators of the past few decades, it will be necessary to work twice as hard; to be twice as smart; and to recognize unknown-unknowns. Fortunately, this is not difficult.

The High Cost of Buying

Law Number VIII addresses the prospect that warfare is pricing itself out of existence.

It can be shown that the unit cost of military equipment, as with much other high technology equipment, is increasing at an exponential rate. Figure 10 shows, for example, the historical trend of rising unit cost in the case of tactical aircraft.

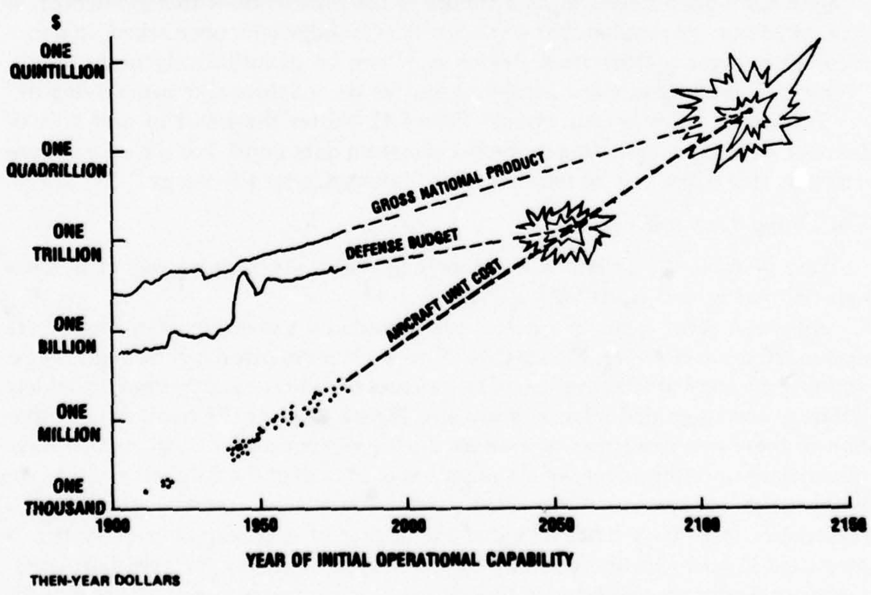
FIGURE 10
Trend of Increasing Cost of Tactical Aircraft



From the days of the Wright Brothers' airplane to the days of modern high performance fighter aircraft, the cost of an individual aircraft has invariably grown by a factor of four every 10 years. This rate of growth seems to be an inherent characteristic of such systems, with the unit cost being most closely correlated with the passage of time rather than with changes in speed, weight, or other technical parameters. The same inexorable trend can be shown to apply to commercial aircraft, bombers, helicopters, or even ships and tanks, although in the last two somewhat less technologically sophisticated instances, the rate of growth is a factor of *two* every 10 years. Seemingly then, the cost of high technology military hardware can be accurately explained in terms of an increase by a factor of four during each sunspot cycle, independent of anything else!

The significance of this observation does not, however, lie in the mere fact that cost growth is, in itself, predictable. Rather, it lies in a *comparison* of the rate of growth of, say, aircraft unit cost with the rate of growth of other relevant parameters, e.g., the defense budget. This particular comparison is presented in Figure 11, wherein the identical data points shown in Figure 10 are reproduced,

FIGURE 11
Calvin Coolidge's Revenge



but to a smaller scale in order to facilitate extrapolation into the future. Objection might be raised as to the validity of any such extrapolation; however, it is noted that the above-mentioned trend has faithfully prevailed throughout the history of aviation, presumably making such extrapolation no more hazardous than that used in most other fields of economic forecasting.

When the trend curves for the national budget for defense and the unit cost of tactical aircraft are, in fact, extended forward in time, as shown in Figure 11, a rather significant event can be predicted for the not-too-distant future. Namely, the curves *intersect*. And they intersect within the lifetimes of people living today. This observation has led to the formulation of Augustine's Eighth Law:

VIII: In the year 2054, the entire defense budget will purchase just one tactical aircraft. This aircraft will have to be shared between the Air Force and Navy 3½ days each per week.

One can only imagine the difficulties that such an arrangement will entail. And it should be pointed out to those who take solace in challenging the validity of the above extrapolation of the defense budget, that, were a plot of the gross national product to have been used instead, the above-mentioned singular event would have been delayed a mere 60 years.

This particular law might, perhaps, more accurately be remembered as "Calvin Coolidge's Revenge" as a tribute to the prescience of that gentleman. It will, of course, be recalled that it was Calvin Coolidge who once asked, in a moment of budgetary frustration (which now can be quantitatively understood), "Why can't we buy just one aeroplane and let the aviators take *turns* flying it?"

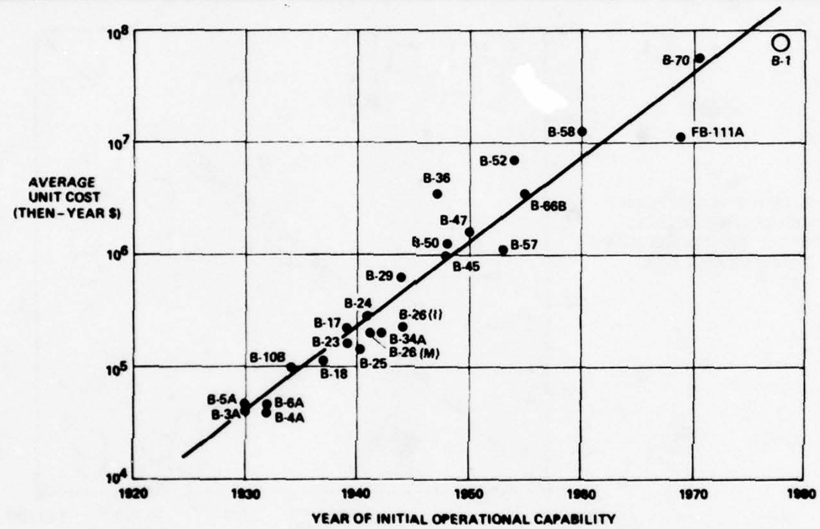
Turning to more recent events, Figure 12 shows the trend in unit cost of bomber aircraft, culminating in the B-1 phantom data point. For the sake of consistency, this curve can be referred to as "Jimmy Carter's Revenge."

On Doing Less with More

Law Number IX describes how one can make a silk purse out of a sow's ear—if, that is, one starts with a silk sow.

Although some types of systems are admittedly expensive, they clearly are also much more effective. Or are they? One such comparison can be made by examining the combat effectiveness of two classes of military systems having widely differing costs—guided missiles and guns. Figure 13 plots the military contribution of these two categories of systems during various major conflicts that have taken place since the advent of the missile age. In each of the conflicts considered, both types of systems were used fairly extensively, thereby providing a reasonably large data base. The combat impact of each category of system is measured in terms of the fraction of a given type of enemy materiel (airplanes, tanks, etc.) which was destroyed by missiles or guns, respectively. The cost of the

FIGURE 12
The Increasing Cost of Bomber Aircraft



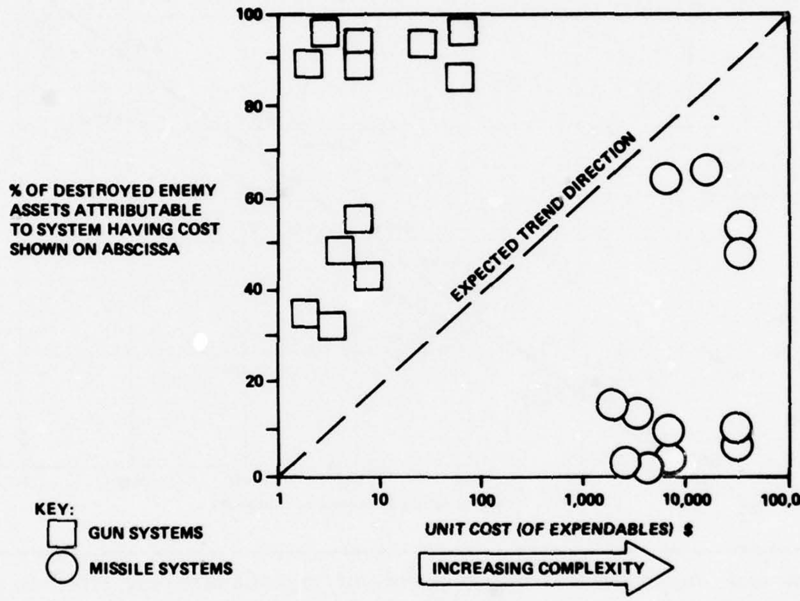
missile and gun systems is measured in terms of "expendables" only, which is, of course, an oversimplification, but which is at least partially justified on the basis that the launchers (aircraft, ships, or the gun tube itself) are reusable.

It might be presumed that the data points in such a comparison would aggregate along the dotted line shown in Figure 12; i.e., the more that one pays for a system, the more it contributes. Disappointingly, the actual data points do not behave according to such a trend at all. Instead, they cluster into two distinct groups as far from the expected line as possible. The data points representing missiles indicate that, at least to date, such systems have had relatively less impact on the outcome of battles than have the far less costly gun systems. This is presumably due in part to the increased susceptibility to countermeasures of the more sophisticated systems; but, more importantly, it is probably due to the fact that as equipment grows more costly it can be afforded in far lesser quantities, thereby sometimes offsetting the hoped-for improvement in individual-item performance.

The next law, thereby derived with a good deal of liberty from empirical evidence, can be stated:

IX: It is true that complex systems may be expensive, but they don't contribute much.

FIGURE 13
Impact of Various Systems in Combat



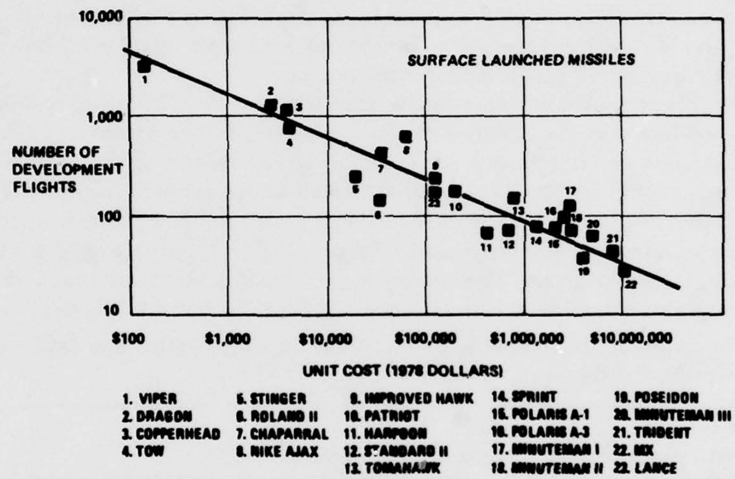
So Simple It Can't Be Trusted

Law Number X concerns the testing of new products and reflects a view expounded by one Casey Stengel, late of the New York Yankees: "I've had no experience with that sort of thing, and all of it has been bad."

Were one to examine the relationship between the amount of testing that is required of a newly developed item and the complexity of that item, it might not be unreasonable to expect that the more complex the item the more testing it requires. If, for example, a chart were made showing the number of flight tests of various missile systems against some measure of their complexity, the trend thereby observed would show a direct correlation, i.e., a line sloping upward to the right.

Not so. Figure 14 presents such a plot, based on the assumption that unit cost is a reasonable metric of "complexity." It is seen that the correlation is *inverse*, sloping *downward* to the right!

FIGURE 14
Relationship of Missile Complexity (Cost) and Number of Flight Tests Required



The amount of testing required thus seems to be more nearly explainable in terms of tradition than in terms of any technical rationale, with relatively simple unguided artillery projectiles somehow demanding thousands of test rounds whereas a new intercontinental ballistic missile needs only a few test flights to demonstrate its adequacy. The less complex the system, the more testing it then requires, a consequence of which forms the basis of Law Number X, the Augustine-McKinley Law:*

X: Truly simple systems are not feasible because they would require near-infinite testing.

As a corollary to the above law, it will be noted that when one knows the number of flight tests which are planned in a missile program, one may use Figure 13 to predict the *unit cost* of the item in question! This requires only a few man-seconds of labor and provides results that compare quite favorably in terms of accuracy with the official cost estimates for most programs during the past two decades.

*Charles H. McKinley, Technical Director, U.S. Army Missile Research and Development Command.

Going Nowhere, but Making Good Time

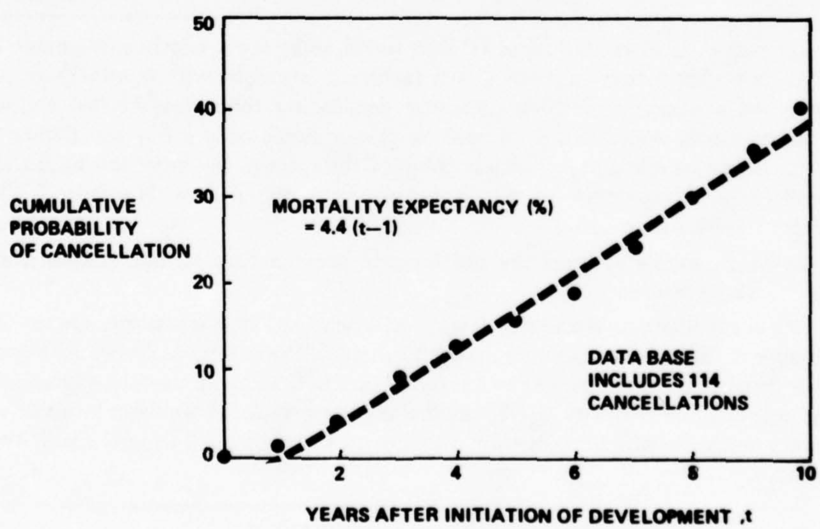
Law Number XI follows an observation made by a well-known college football coach: "The light at the end of the tunnel may be a freight train."

One consequence of the myriad of problems examined above is a relatively high mortality rate among development programs. This is a condition which, incidentally, is rarely reflected in a contractor's long-range sales plan, but which nonetheless is highly predictable in the aggregate.

The data presented in Figure 15 are derived from over 300 defense-related programs conducted in the past two decades. They reveal the probability that any given program will fail to survive the threats to its existence which arise prior to any given year in its life. It is seen that there is about a 4-percent probability of cancellation of a program each and every year except for the first year, sometimes referred to as the honeymoon period. This probability appears to be relatively independent of program age, presumably even for such aged endeavors as two current programs which soon will have been in development for 18 years.

XI: In terms of their chances of surviving, most programs start out kind of slowly and then sort of taper off.

FIGURE 15
Survival Expectancy of Development Programs

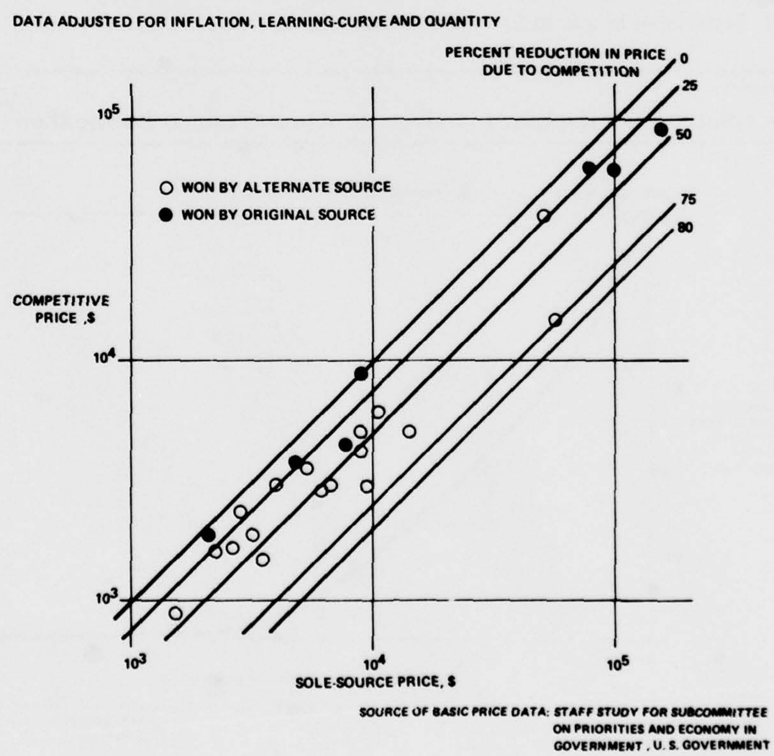


Do They Know Something We Don't?

Law Number XII examines a process similar to one once critically referred to by an executive of the Lockheed Aircraft Corporation as "You bet your company."

One of the most effective means of controlling cost while achieving good product performance is competition. But even competition must be applied carefully, or unwanted results occur. Consider, for example, the practice occasionally used in Department of Defense procurements of awarding the production contract for a newly developed system to whomever is the low bidder. This has the unquestioned impact of driving down the bid prices, and the disadvantage of sometimes

FIGURE 16
Effect of Competition on Unit Price



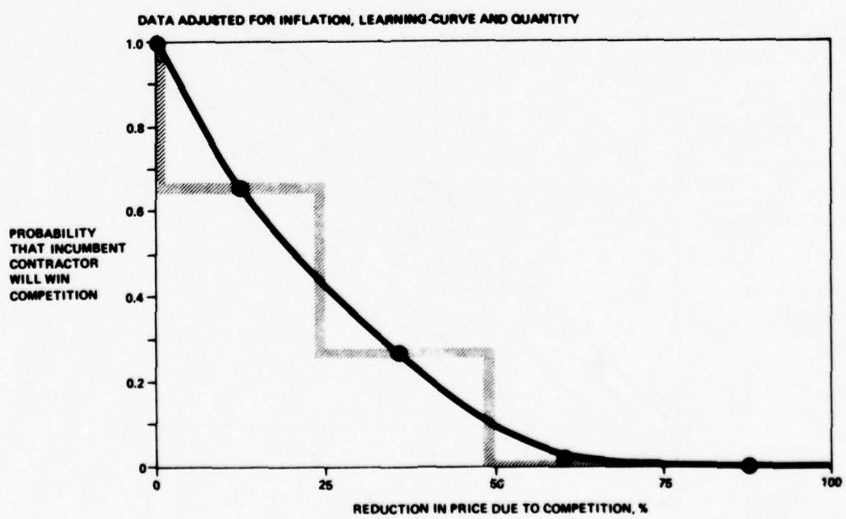
creating a producer who has no familiarity with the hard-earned lessons of how one actually goes about producing the product in question, lessons which were learned over many years of effort by the developer.

The data in Figure 16 verify that major bid price reductions are indeed obtained by competing a number of potential producers for an item developed by one specific contractor. (This figure does not, however, examine whether the winning bidder was ever able to actually manufacture a useful and reliable end product at the bid price—or any other price.)

Figure 17 examines the data in Figure 16 in a slightly different fashion. It indicates that the greater the winning price reduction relative to the developer's original price, the less likely is the developer of the item in question to be the winning bidder. It appears that an intimate knowledge of the task to be performed is somehow a handicap. Several interpretations are, of course, possible, one of which is expressed thusly (with apologies to Alexander Pope):

XII: Fools rush in where incumbents fear to bid.

FIGURE 17
The Ability of an Established Producer to Win a Breakout Competition



SOURCE OF BASIC PRICE DATA: STAFF STUDY FOR SUBCOMMITTEE ON PRIORITIES AND ECONOMY IN GOVERNMENT, U.S. CONGRESS

It was this law which an Army aviator, with whom the author once flew, had in mind when he added to the warning and caution stickers that traditionally abound in the cockpits of modern rotary-wing aircraft, this hand-lettered admonition: "Caution. This helicopter built by the lowest bidder."

The Budget Equation

Law Number XIII concerns the impact of the congressional appropriations process in defense system management.

In order to survive to completion, every government development program must maintain an extremely high single-skirmish-survival probability in its encounters with the various steps in the budget cycle. In the congressional approval process alone, a defense program's budget will be voted on at least 18 times a year, or a total of 144 times in the average program's lifetime. It does not seem to be possible to determine *a priori* the probability that any particular program will be funded or terminated by the Congress in any given year. It is, however, possible to predict with very good accuracy what the *overall* impact of the congressional approval process will be on the defense budget; that is, the result, in the aggregate, of the yearly congressional review process can be reduced to an equation.

Figure 18 displays the effect of congressional actions on the administration's defense budget requests in each year of the present decade. It is seen that a trend line can be quite accurately drawn which will predict the outcome of the congressional review process on the budget of any given military department, or on the Department of Defense as a whole. This would suggest that the Administration's efforts to gain approval of its budget requests have about the same impact year after year, independent of the political parties involved or the magnitude of the budget change requested, the latter even over quite large excursions.

These observations are summarized as follows:

XIII: In any given year, the Congress will appropriate for defense the amount of funding approved the prior year plus three-fourths of whatever change the administration requests, minus a 4-percent tax.

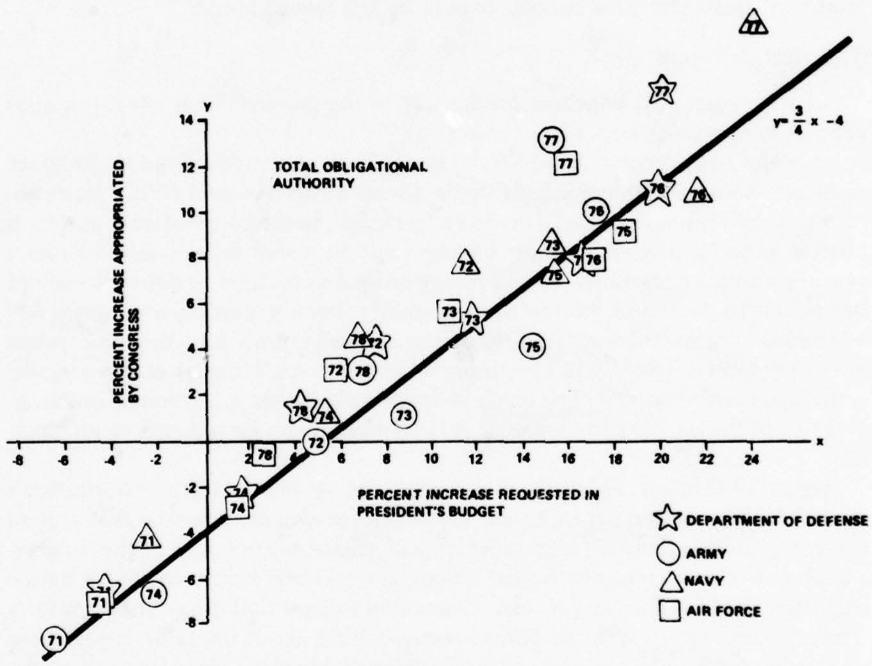
During the present decade, this law has applied with good accuracy over a ange of year-to-year changes in the requested funding level extending from minus 7 percent to plus 24 percent. This is shown in the above-mentioned figure.

On Making a Precise Guess

Law Number XIV examines the parallel between management decision-making and Bismarck's observation about law-making. "Law," he said, "is like sausage: if you like it, you shouldn't watch it being made."

As reported to the Congress at the time development was to be initiated, the total program cost for the Harpoon missile program was said to be $1,031.8

FIGURE 18
Predicting Congressional Changes to the Defense Budget Request

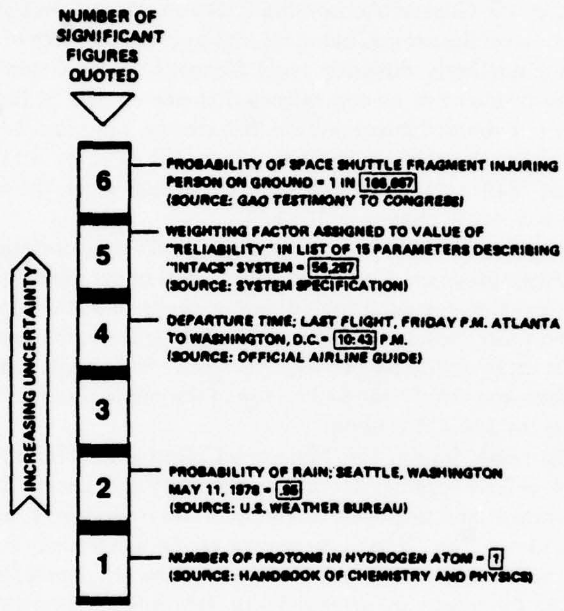


million. For the A-10 program, the corresponding cost was defined as $2,489.7 million—not $2,400 million; not even $2,489 million. Rather, the cost would be two thousand four hundred eighty-nine *point seven* million dollars.

This great degree of accuracy may perhaps be somewhat surprising to the uninitiated in view of the fact that history shows the *first* digit of past program cost estimates to have been in error, on the average, by about 100 percent! The General Accounting Office, in its most recent report on the topic, for example, has stated that for Department of Defense acquisition programs now underway, 67 percent are already overrun by more than 100 percent.

Nonetheless, by examining the data in Figure 19, it is possible to derive the logic which underlies the practice of quoting fundamentally dubious numbers with a very great degree of apparent accuracy. It is seen from the figure that there is indeed a relationship between the number of "significant figures" quoted and

FIGURE 19
Relationship of Implied Precision to Actual Precision



the true precision of the data at hand but this relationship is just the opposite of what one might expect. My next law, which is based on a substantive collection of data such as that presented in Figure 19, states:

XIV: The weaker the data available upon which to base one's position, the greater the accuracy which should be quoted in order to give that data an aura of authenticity.

A problem which has long been faced in applying Law Number XIV, however, has been what to do in those cases wherein the analyses from which the numbers were derived provide only rather discrete results, such as $1 billion, or 10 miles or 1 ton. The solution to this dilemma has been astutely observed by Lieutenant General Glenn A. Kent (USAF, Ret.) in his reviews of a large number of quantitative analyses. The solution consists simply of converting all data from the English system of measures into the metric system and back again!

A derivative of this technique accounts for such phenomenal accuracies as are identified in a bulletin recently carried by a U.S. wire service concerning a British

citizen whose private airplane was reported to have missed crashing into the control tower at an airport in England "by less than 39.4 inches."

A related approach appears to have been used last year in testimony provided to the Congress by the General Accounting Office in which it was stated that the chances of a person on the ground being injured by a falling piece of a space shuttle launched in a northerly direction from Kennedy Space Center "are one in 166,667." It may or may not be coincidence that one change in 166,667 equates almost precisely to 6 divided into a million. But clearly, one would not feel nearly as safe knowing that the chances of being hit on the head by a falling piece of shuttle are about "half a dozen in a million" as he feels when the probability of that happening is a single chance in 166,667.

Still another approach underlies the fiscal year 1979 appropriation of $25.418 million for the Aegis program. Certainly, a great deal of detailed study must have been required to define the program's funding needs in such detail. But, alas, when scrutinized more closely it is found that the figure is the result of a compromise brought on by a dispute between the House and Senate whereby a lump sum of $11 million was simply patched on top of the original request by the President, which was for $14.418 million!

Actually, Sir Josiah Stamp, Her Majesty's Collector of Inland Revenue, was well on the track of Law Number XIV nearly a century ago, except that he applied it only to government and neglected its frequent use by industry, among others. Sir Stamp pointed out that: "The Government are [*sic*] extremely fond of amassing great quantities of statistics. These are raised to the *n*th degree, the cube roots are extracted, and the results are arranged into elaborate and impressive displays. What must be kept ever in mind, however, is that in every case, the figures are first put down by a village watchman, and he puts down anything he damn well pleases!"

Growing Like a Regulation

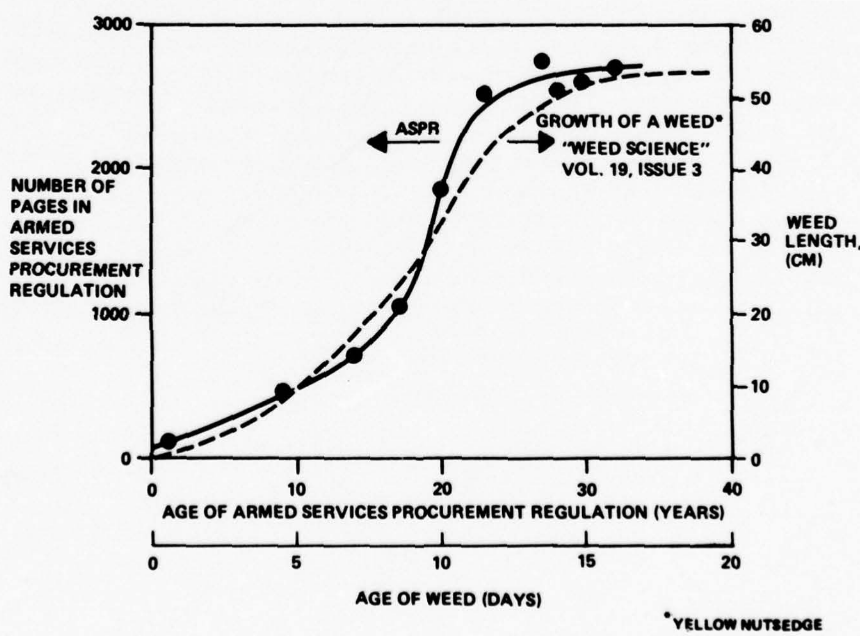
Law XV provides the mathematical foundation for Lamennais's apothegm, which states: "Centralization breeds apoplexy at the center and anemia at the extremities."

Large organizations, probably epitomized by federal governments, seem to be susceptible to the concept that regulations can become a substitute for management. Today, for example, the U.S. Government has imposed a set of 23,000 specifications on those who would sell to it a simple mousetrap. But, in spite of all the established rules, it is soon discovered that special cases occur, each requiring still further rules. And, of course, as new rules are added, none of the old rules is ever discarded; none, that is, until the entire management-by-regulation concept collapses of its own weight and a new cycle begins based on an altogether new set of regulations.

One particularly interesting but not atypical example of the growth of regulations is to be found in the Armed Services Procurement Regulation (ASPR) which governs procurement of everything used in the nation's defense, from aircraft carriers to the paper on which the ASPR itself is printed. Figure 20 shows the rate of growth of ASPR over its lifetime, and verifies that it indeed exhibits a behavior consistent with well established growth processes observed in nature. It is also noted that, based solely on its growth pattern, the ASPR appears to have reached its terminal phase—after which it can be expected to be replaced by a new set of policies.

The degree of improvement wrought by these growth trends, as they have prevailed over the years, is suggested in the case histories of two airplanes. When the Army Signal Corps purchased the development of an aircraft from the Wright Brothers, the entire contract (a fixed-price incentive type) comprised two pages. It was the result of a 40-day competition among 41 bidders, which was culminated in a 9-day evaluation period by the government. An award was made (without

FIGURE 20
Growth of a Regulatory System



protest) and the aircraft flew successfully 6½ months later. The primitiveness of this management system contrasts sharply with the more sophisticated approach used today which, in the case of the giant C-5A transport, generated contractor proposals, the paper for which would have more than filled the C-5A itself. We are thus led to:

XV: Systems of regulations created as a management surrogate take on a life of their own and exhibit a growth history which closely parallels that of selected other living entities observed in nature.

Summary

Augustine's Laws, largely derived from empirical evidence, might be interpreted as suggesting that it is simply not possible to develop major systems. Such is not the case. This is demonstrated by the many successes achieved by many able and dedicated managers. What they do suggest is that the *unwary* manager will very likely fall victim to phenomena which are every bit as predictable, and every bit as invincible, as processes governed by the physical laws of nature. ‖

77

Mission-Area Resource Allocation for Air Force R&D

Colonel Thomas C. Brandt, USAF
Lieutenant Colonel Howard E. Bethel, USAF
Captain Wallace B. Frank, Jr., USAF

One of the most important peacetime activities of the Department of Defense (DOD) is deciding how to invest limited available resources to maximize future combat capability. All elements of each service are involved, but the hub of activity is at the headquarters level where the Five Year Defense Program (FYDP) is prepared.

Today's world of tight budgets means that tough decisions must be made involving trade-offs between investments in modernization, readiness, and force structure. These decisions determine the course of individual acquisition programs and thereby define future war-fighting capability.

The resource allocation process used in the Air Force Deputate for Research, Development and Acquisition (AF/RD) to build the Air Force research, development, test and evaluation (RDT&E) program for Fiscal Year 79 was the prototype for the current effort to mission-base all portions of the Air Force program. As such, it is an important link in the rapidly evolving Department of Defense resource allocation process. This article describes this prototype—the mission area planning, programming, and budgeting process.

An understanding both of the forces driving the resource allocation process toward a mission orientation, and of the recent experience with mission-area analysis provides the foundation for a more complete understanding of the mission area planning, programming, and budgeting process of today. The process itself is described in its two stages of development: the initial process developed for the RDT&E part of the FY 79-83 budget estimate submission (BES) of 30 September 1977, and the revisions made for the FY 80-84 program objective memorandum (POM), which served as the underpinnings for the Air Force portion of the President's FY 80 budget request.

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Captain Wallace B. Frank, Jr., USAF, is a program analyst in the Formulation and Analysis Division, Deputy Directorate for Program Integration, Deputy Chief of Staff, Research, Development and Acquisition, HQ USAF. He was the action officer charged with devising and implementing missionized resource allocation, the result of which was the mission area planning, programming and budgeting process. Captain Frank holds an M.S. degree from the University of Southern California.

Catalysts for Change

There has been a constant striving to improve the resource allocation process in the DOD. The planning, programming and budgeting system (PPBS) now in use was first implemented and systems analysis emphasized during the years when Robert McNamara was the Secretary of Defense. These initiatives tended to motivate a program-element-by-program element review of service programs. However, recent actions suggest that a more macro, mission-area approach is beneficial for putting individual programs in a broader perspective. Since these actions have caused substantive changes in the resource allocation process, their origins are worth examining.

One important catalyst was the Report of the Commission on Government Procurement published in late 1972. Among the committee's recommendations, one specifically focused on the use of mission-area analysis:

> Begin Congressional budget proceedings with an annual review by the appropriate committees of agency missions, capabilities, deficiencies, and the needs and goals for new acquisition programs as a basis for reviewing agency budgets.[1]

Another catalyst was Section 601 of the Congressional Budget and Impoundment Control Act of 1974. It requires that a mission-oriented display of an agency's program be presented to Congress each year:

> The Budget transmitted...each fiscal year, beginning with the fiscal year ending September 30, 1978, shall contain a presentation of budget authority, proposed budget authority, outlays, proposed outlays, and descriptive information in terms of
> (1) a detailed structure of national needs which shall be used to reference all agency missions and programs;
> (2) agency missions; and
> (3) basic programs.
> To the extent practicable, each agency shall furnish information in support of its budget requests in accordance with its assigned missions in terms of Federal functions and subfunctions, including mission responsibilities of component organizations, and shall relate its programs to agency missions.[2]

The DOD evolved a mission-area breakout in response to this requirement and used it as one of the displays in submitting the FY 79 President's budget. At that time, the Deputy Secretary of Defense reported that "considerable difficulty

1. "Acquisition of Major Systems," Part C, Report of the Commission on Government Procurement, December 1972, Volume 2, p. 78.
2. Congressional Budget and Impoundment Control Act of 1972, Public Law 93-344, 93rd Congress, July 12, 1974.

was encountered in missionizing the support areas and more work remains to be done in this area."[3]

A third catalyst for change was a General Accounting Office report on mission budgeting issued in July 1977. The report first criticizes the current process: "...Congress gets a great mass of detail, not a coherent picture of what the money is for and why it is needed."[4] Then, it suggests that mission budgeting, including reporting to Congress in a mission format, would be a preferable approach. However, the report stops short of advocating an immediate, complete change, recommending instead a test of mission budgeting. Examples in the report focus on the R&D programs of DOD, the National Aeronautics and Space Agency, and the Department of Energy, formerly the Energy Research and Development Agency.

A final catalyst, and probably the most precipitous, was the incorporation in the Federal budget process of zero-base budgeting with its difficult requirement of prioritization. Establishing priorities requires a comprehensive and fair framework for evaluating programs. The structure used to analyze missions and the knowledge that analysis yields can fulfill this need, making a mission-area-analysis based approach to resource allocation a natural partnership with zero-base budgeting.

Historical Mission Area Efforts in Air Force R&D

The concept of mission-area analysis is not new. Its beginnings can be traced at least as far back as the late 1960s when then Colonel (later Major General) Kenneth Chapman, Deputy Director for Requirements, Plans, and Analysis, undertook a requirements/budget study. His approach was conceptually straightforward and embodied the familiar scientific method. The current approach is a direct descendent. An outcome of this study was the preparation of a proposed budget based on a first-cut, mission-area analysis. However, this budget position was considered so preliminary that it was held within Colonel Chapman's directorate and apparently did not visibly impact the overall budget formulation process. As an outgrowth of this effort, emphasis was placed on upgrading available information on major weapon system capability.

Beginning in 1970, capability master plan documents, which summarized the existing and planned capability of individual systems, were developed by the Air Force Deputy Chief of Staff for Research and Development. These were discontinued in 1972 because of the difficulty in keeping them up-to-date and in identifying a specific use for the information they contained. This problem of effectively using mission analysis findings in the resource allocation process is difficult and has plagued all subsequent efforts.

3. Charles W. Duncan, Letter to Senator Edward Muskie regarding Missionized Display for DOD, October 8, 1977.

4. Mission Budgeting: Discussion and Illustration of the Concept in R&D Programs, General Accounting Office Report PSAD-77-124, July 27, 1977.

In 1974 a new undertaking to couple mission-area analysis to the resource allocation process was initiated by Colonel John R. Boyd. His work led to an Air Staff-wide exercise to define basic combat tasks and hardware options. Detailed total program analysis was also done; this resulted in focusing attention on the "bow wave" problem in the investment accounts, that is, the tendency to defer planned programs that are not affordable, thereby swelling out-year demands beyond reason.[5] Once more, there was no direct, traceable imprint on subsequent allocation decisions. Despite this, the work is significant because it was the basis for the integrated mission-area analysis concept presented as a management proposal in the Systems and Resources Management Action Group report published in January 1976. The report introduces the concept as follows:

> ...integrated mission area analysis is a method to arrive at alternative forces, acquisition strategies, and RDT&E options that can be logically linked and aligned for presentation to decision makers in a disciplined, systematic fashion.[6]

This proposal, in turn, sparked the events which led to a process in AF/RD which appears to have affected the resource allocation decision process.

A renewed effort to use mission-area analysis as a basis for resource allocation began in the summer of 1976. The objective was to influence the formulation of the RDT&E program in the FY 79-83 programming cycle.

A set of mission areas was defined and key people were designated to be mission-area chairmen. These chairmen were tasked to do a mission-area analysis to support the resource allocation process; however, little specific methodology guidance was provided. Moreover, differing perceptions of its importance on the part of the "doers" led to a wide variance in the quality of the products. Notwithstanding, a "POM strategy" document based on the analysis was circulated to RD directors for their use during formulation of the program objective memorandum. The mission-area chairmen attended POM development meetings of the Budget Committee, but only in an advisory role. (The Budget Committee, composed of the RD directors and chaired by the Deputy Chief of Staff for R&D, is the key AF/RD resource allocation decision body.) This advisory role of the mission-area chairmen was not well defined and as a result they made a limited contribution.[7]

A fundamental conclusion drawn from this and previous mission analysis ventures was that if mission-area analysis was to have a substantive effect on

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5. John R. Boyd, Development Planning-Interim Report, AF/RDQL, HQ USAF, August 1974.
6. Integrated Mission Area Analysis, Management Proposal No. 4, Systems and Resources Management Action Group, HQ USAF, January 1976, pp. 4-7, 4-8.
7. Ronald C. Allen (Colonel, USAFR), An Evaluation of Mission Area Analysis Within DCS/RD, End of Reserve Tour Report, March 18, 1977.

resource allocation decisions, it had to be an integral part of that process. Because of this conclusion, the Deputy Chief of Staff for R&D, Lieutenant General Alton D. Slay (now General Slay, Commander, Air Force Systems Command) in June of 1977 decided to couple mission analysis with the RDT&E resource allocation process. What emerged is referred to as mission area planning, programming, and budgeting (MAPPB) because it includes three phases: (a) mission area analysis, (b) functional planning, and (c) zero-base programming/budgeting. The MAPPB process as implemented for the FY 79 BES is summarized below.

Initial MAPPB Effort in AF/RD—FY 79-83 BES

A mission-area structure was created within the deputate and matrixed with the functional organization. This, in effect, meant that all the programs assigned to AF/RD for management were viewed from the two perspectives of function and mission area. How this matrix worked is explained later, but first a word about the players. A chairman was assigned to work each mission area. Most of the mission-area chairmen were division chiefs who had functional responsibilities related to their mission area; but, in no case did a mission-area chairman functionally manage all the programs assigned to his mission area. The functional and mission organizations came together within the *AF/RD Budget Committee*. Two points of view were brought together: the programmatic from the functional directors, and mission capability/needs from the mission-area chairmen. The major objective of the organization matrixing was to bring more information to bear on the resource allocation decision process, particularly the aggregates of mission capabilities/needs. From these inputs the Budget Committee built a strawman budget.

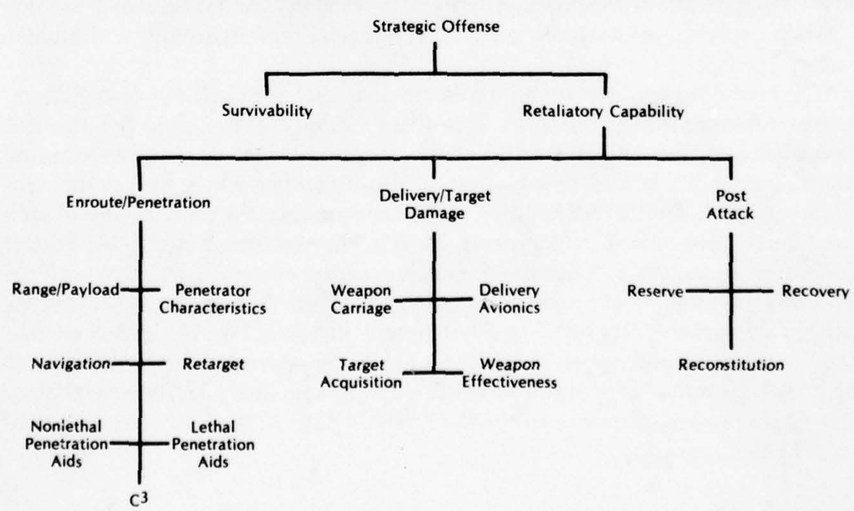
The methodology used by both mission-area chairmen and the Budget Committee in accomplishing this work is in theory simple, although in practice it is somewhat complex—and difficult! The mission-area chairmen analyzed near-and far-term capability in each mission area to identify and prioritize the key deficiencies amenable to an RDT&E solution. They then assessed the contribution of each program element in their mission area. Finally, they recommended to the Budget Committee three levels of funding for each program element consistent with the proposed investment strategy for their area. These would normally be accomplished sequentially, but they overlapped significantly during budget estimation because of the short time available (June through September). This methodology is the heart of the MAPPB: mission-area analysis, functional planning (development planning in the case of AF/RD), and zero-based programming/budgeting.

MISSION-AREA ANALYSIS

The objective of the analysis phase is to define "the problem" for each mission area. Although an analysis was accomplished for each of 11 major areas, it quickly became clear that our approach to the analysis was most applicable to combat-related missions. For example, some adjustments had to be made when analyzing the technology base, management and support, and defense-wide areas. The basic mission-area analysis process used consists of the following steps: (1) build a framework for the analysis; (2) identify capability deficiencies over time in the context of the relevant threat; and (3) assess the need to make improvements.

The first step is to define the framework. The framework includes the tasks which must be accomplished to achieve mission success, the conditions under which these tasks must be performed, and the relative importance of each. For example, the strategic offense area was divided into survivability and retaliatory tasks. These were then further subdivided into more detailed tasks, as illustrated in Figure 1, to form one side of an evaluation matrix. The second side is composed of the conditions under which each mission is performed. Points on the political-military spectrum were chosen as conditions for the strategic offense area. They were "general war," "limited war," and "crisis." An example evaluation matrix for the strategic offense area is at Figure 2. Weights for the relative im-

FIGURE 1
Functions Considered in Strategic Offense Mission Area



portance of each task and condition were assigned. On the task side, the importance weight reflects the "value" of each task to total mission success. The condition weights, however, indicate how critical each probable condition is as a basis for planning.

Once the framework is defined, the next step is to assess, over a period of time, the deficiencies in ability to accomplish a particular task under a specific condition, i.e., for a cell in the matrix in Figure 2. To make the evaluation definitive, it is necessary to specify the projected capability of both U.S. and enemy forces. For this assessment, particular points in time were chosen. For example, the then current (FY 78) capability was measured against the (FY 78) threat and then against two projected threats—FY 83 (the end of the FYDP) and FY 88 were used. This kind of comparison results in a zero-based assessment of how threat changes will impact our capability, assuming no planned modernization. This assessment is made for each task/condition pair and for each capability/threat time frame. Because of a lack of quantitative tools and data, our assessment was based on objective criteria such as parametric study results, hard test data, or actual combat experiences. Three basic categories of deficiency were used: inadequate, marginal, or adequate.

Such an assessment of deficiencies alone does not definitize the problem adequately for resource allocation decisions. It is necessary to couple each deficiency with its relative importance when determining the need to make improvements. We refer to this resultant quantity as "need." The absolute value of a need is not significant *per se*; only its relative value has meaning when compared to a range of possible values. The need is summed over all conditions for a particular task. A similar process is followed to determine the condition need. Finally, the total need for the area is obtained by summing the task or condition need values. These total mission need values are then plotted as a function of time, as illustrated in Figure 3, and give the decision-maker a gross indication of the well-being of a mission area.

To summarize, the mission-area analysis phase of the process defines the problem and provides the key information needed to prioritize alternative programs according to their contribution to overcoming capability deficiencies. Prioritization of alternatives is the essence of the next phase of MAPPB—development planning.

DEVELOPMENT PLANNING

The development planning phase includes: (1) the identification of workable program alternatives; (2) an assessment of their contribution to satisfying deficiencies; and (3) the building of possible development strategies.

The first action in Step 1 is to narrow the problem. For any deficiency there are likely to be several possible solutions, only some of which involve RDT&E.

FIGURE 2
Evaluation Matrix for Strategic Offense

STRATEGIC OFFENSE FUNCTIONAL TASK BREAKDOWN CAPABILITY/DEFICIENCY (U)

CONDITION	TASK	SURVIVABILITY									
		PRE–LAUNCH				LAUNCH			ENROUTE/		
		Response Options	C^3	Basing	Hard–ness	C^3	Avail–ability	Escape	Navi–gation	Re–target	
GENERAL WAR	ICBM										
	AIRCRAFT										
LIMITED WAR	ICBM										
	AIRCRAFT										
CRISIS	ICBM										
	AIRCRAFT										

For example, tactics could be changed; more systems currently in production could be bought; an existing system could be modified; or, finally, a new system could be developed. The last two approaches would require RDT&E. For those deficiencies where a development solution is indicated, program alternatives are identified in terms of cost, schedule, and technical content.

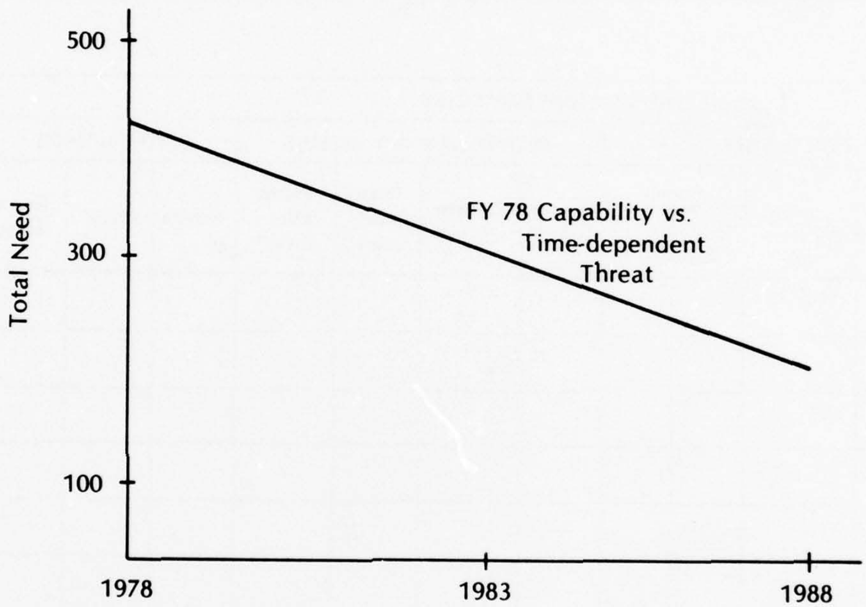
In the second step, the extent to which a program contributes to overcoming a deficiency, and the importance of overcoming that deficiency, are assessed. The analytical approach is simple, perhaps even crude, but proved useful, especially for "the first time around," where proof of process was the major objective. The contribution a program made to overcoming a deficiency is evaluated on a scale of 0-9 as shown in Figure 4. For an individual program element (PE) the contribution to each task/condition cell is recorded and a cell program value calculated by multiplying the PE contribution by the importance weights. The program value for the PE is obtained by summing over all cells. When all the program alternatives have been assessed, they are rank ordered, thus providing the basis for subsequent considerations.

RETALIATORY CAPABILITY											
PENETRATION					DELIVERY/TARGET DAMAGE				POST ATTACK		
Range/ Payload	C^3	Pene- trator Character- istic	Penaids		Weapon Carriage	Delivery Avionics	Target Acqui- sition	Weapon Effec- tiveness	Reserve	Recover	Recon- stitute
			Non- Lethal	Lethal							

The last step in the development planning process is conceptualizing possible alternative development strategies for a mission area composed of various mixes of program alternatives. These development strategies, although not rigidly bound by tight fiscal constraints, must at the same time be fiscally reasonable to be considered viable. In the strategic offense area, possible development strategies might be: (1) primary dependence upon penetrating bombers, secondary dependence upon cruise missiles; (2) exclusive dependence upon cruise missiles, phase-out of penetrating bombers; (3) primary dependence upon land based missiles, secondary dependence upon cruise missiles; and so forth. Various out-year programs may be compared by postulating the out-year capability of each program and comparing it with the relevant threat, i.e., FYDP program vs. FY 83 threat and then FY 88 threat. This extrapolates from the zero-base established in the mission-area analysis phase.

These development strategies are the basic input to the next phase of optimizing the total RDT&E program within tight fiscal constraints—zero-base programming and budgeting.

FIGURE 3
Mission Area Need Trend



ZERO-BASE PROGRAMMING/BUDGETING

The zero-base programming/budgeting phase includes: (1) grouping program elements into decision units; (2) formulating mission-area investment strategies; and (3) integrating the RDT&E program into the total Air Force program/budget.

Since this initial effort was introduced in the budgeting phase of the PPBS, "zero-base programming" *per se* is not addressed; however, the logic described below applies. In the first step, the PEs within each mission area are grouped into related sets and referred to as decision units. For example, in the "strategic offense" mission area the PEs were grouped under "airborne strike" and "land-based strike." These groupings permitted closely related PEs to be considered together in the process.

The next step, formulation of the mission-area investment strategy, is the crux of this phase and the entire process. The mission-area chairman uses the results of his development planning efforts to develop an optimized program within the fiscal limitations imposed on his area. Once a program is formulated, it is tested using the matrix charts (Figure 2) to show what areas improve and where residual deficiencies remain; then the program is adjusted—an iterative process. The final

FIGURE 4
Program Contribution Valuation for BES

PROGRAM VALUE = IMPORTANCE X PE CONTRIBUTION

Program Contribution	Deficiency	PE Contribution Value
Major	Critical	9
Major	Very Important	8
Major	Important	7
Moderate	Critical	6
Moderate	Very Important	5
Moderate	Important	4
Minor	Critical	3
Minor	Very Important	2
Minor	Important	1
None		0

results are presented to the Budget Committee, and the distribution of funds between mission areas is adjusted until the payoff of the total RDT&E account is optimized to the degree possible. This is admittedly a subjective process, but one in which the mission-area process brings more information to bear than had previously been available to the decision-makers. In the FY 79 BES cycle, all RDT&E programs were formulated at three fiscal levels: enhanced, basic, and decremented.

The last step of integrating the RDT&E program into the total Air Force program/budget is done through a series of briefings to the Air Force Board Structure, the Air Staff's corporate review body. There the inevitable last-minute changes are made to ensure harmony across all appropriations. The final product is transmitted to the Office of the Secretary of Defense as part of the Air Force budget estimate submission.

FIGURE 5
Program Contribution Valuation for POM

PROGRAM VALUE = IMPORTANCE X DEFICIENCY PE CONTRIBUTION

Program Contribution	PE Contribution Value
Major Contribution: Sufficient to Improve 2 Colors on Capability Scale (Guarantee "Green")	7-9
Significant Contribution: Sufficient to Improve 1 Color on Capability Scale	4-6
Some Contribution: Ordinarily, By Itself, Not Enough to Move Up a Color on Capability Scale (Cannot Correct a Deficiency)	1-3
No Contribution	0

CRITIQUE OF THE FY 79 BES PROCESS

The results of the initiative of mission-area planning are ambiguous. There is a general belief in the deputate that a better understood, more defendable program resulted from the process. Furthermore, Office of Management and Budget analysts commented that it was probably the best structured program they had seen. However, OSD/OMB, in making their budget adjustments, reduced the proposed Air Force R&D program about 9 percent!

A quick statistical analysis of the program changes, from the time of submission by the Air Force to the President's budget, suggests that changes in seven of the mission areas were mainly "fine tuning," while significant redirection occurred in the other four areas. This specific redirection in major program decisions accounted for most of the 9-percent reduction. This may reflect affordability concerns more than concern with overall program structure and content. A cause-effect relationship is difficult to establish here. In only a few cases were the mission-area results themselves presented to working-level analysts in OSD/OMB. Thus, it appears the main impact that mission-area analysis had on the process was implicit, namely in the quality of the program submitted to OSD/OMB.[8]

8. Stanley R. Spector (Colonel, USAFR), and H. Lawrence Elman (Major, USAFR), Impact of AF/RD MAP on FY 79 President's Budget, End of Reserve Tour Report, 12 May 1978.

Despite shortcomings in the initial effort to tie mission analysis directly to the budgeting process, the Deputy Chiefs of Staff recognized its potential and agreed to broaden the application of the process.

MAPPB for the FY 80-84 Cycle

The mission-area approach was extended to an Air Staff-wide process for the Fiscal Year 80-84 cycle.[9] The Deputy Chief of Staff/Plans and Operations (AF/XO) took the lead in the mission-area analysis phase. Within AF/RD, this analysis, as before, was used as an input to development planning. But this time the process was significantly improved by increased Air Force Systems Command (AFSC) participation; an improved R&D program valuation technique; and the generation of a more extensive set of program alternatives. In the zero-base programming/budgeting phase, the old three-level approach was changed to one of formulating a program at a basic level and defining increments and decrements around the baseline.

MISSION-AREA ANALYSIS

The AF/XO organized a massive effort in September-December 1977 to accomplish a mission-area analysis to support the Fiscal Year 80-84 cycle. An *ad hoc* core group orchestrated the analysis, and Air Staff-wide working groups in each mission area became the "doers and reporters" of the analysis. These "doers" obtained and used the results of existing major command mission-area analyses.

The working groups used a methodology which was an extension of the AF/RD work. The basis for the evaluation of deficiencies and needs was extended to include force size and readiness-related tasks. These changes allowed an overall perspective across mission areas and aided in the task of prioritizing the total Air Force program.

The product of this mission analysis was an *Air Force Planning Guide*, formally published in January 1978. The report includes a prioritized list of increments of capability, matrices of tasks and conditions for each mission area, deficiency and need charts similar to those first used by AF/RD, and a prioritized list of needs. In addition to publishing the guide, the Mission Element Working Group chairmen briefed both the functional staff and the appropriate Air Staff Board panels charged with recommending program alternatives to the corporate review body.

DEVELOPMENT PLANNING

There were several changes in the development planning phase. Whereas during the Fiscal Year 79 BES, program alternatives were generated within AF/RD,

9. Memorandum of Understanding on Air Staff Approach to Mission Area Planning, Programming and Budgeting, HQ USAF, 19 September 1977. Although final version was only signed by five of the six DCSs, this document has served as the plan for Air Staff-wide implementation of MAPPB.

during the Fiscal Year 80-84 exercises they were obtained from the research and development field organizations and validated by Headquarters, Air Force Systems Command. Furthermore, HQ Air Force Systems Command, working closely with AF/RD, made total program recommendations throughout the POM formulation phase. Another improvement was a new approach to program valuation. In the BES, program value was defined as:

PROGRAM VALUE = IMPORTANCE X PE CONTRIBUTION

where the contribution of the PE to overcoming a deficiency and the deficiency itself were incorporated in the term "PE contribution." In the new approach, these were made independent elements; namely:

PROGRAM VALUE = (IMPORTANCE X DEFICIENCY) X PE CONTRIBUTION

or

PROGRAM VALUE = (NEED) X PE CONTRIBUTION

The need value has been determined as part of the mission analysis and was used directly as an input to the development planning work. Program element contribution then was focused solely on the technical contribution of a PE to overcoming a deficiency, as indicated in Figure 5. Using this valuation technique, supplemented by judgment, the alternatives were prioritized within each mission area. These prioritized lists were used in the process of "balancing the pain" between mission areas in the zero-base programming/budgeting phase.

ZERO-BASE PROGRAMMING/BUDGETING

In the zero-base programming/budgeting phase there were no major changes in the RD approach to the allocation of limited resources. However, a change in the overall Air Staff approach resulted in only one program being formulated at the basic level with increments and decrements to this level generated within the Air Force corporate board structure. These increments and decrements provided the programmatic changes to get to an enhanced or decremented level, respectively.

Where We Go From Here

The deficiencies noted in the FY 80-84 MAPPB process are in many ways similar to those first encountered within AF/RD the year before when the mission approach was first used. In the analysis phase, the *Air Force Planning Guide* was prepared in 3 months. While a good first effort, there remain some concerns regarding its credibility as the basis for the total POM formulation. In the subsequent phases, there were problems in effectively using the results of analysis in formulating the program. One was the makeup of the Air Force Board Structure

panels. They were a mixture of mission and functional groups which did not correlate well with the mission analysis structure. Also, the detailed nature of mission analysis tended to make it difficult to communicate the impact of various program options to senior executives. For the purpose of development planning, *Air Force Planning Guide* mission-area analysis inputs were acceptable and widely used; but, in a few cases adjustments had to be made. Also, in development planning, the technique for valuing the program element contribution remained controversial.

Improvements to both the development planning and zero-base programming/budgeting phases within AF/RD are strongly tied to changes in the overall process. There are more improvements "in the wings." One is an increased use of automatic data processing (ADP) to reduce the work. The key areas for ADP improvement are in accounting and decision documentation. Another planned improvement is in program element valuation. While valuation is closely tied to the course of the total process, two initiatives underway are specifically directed to the valuation of R&D program elements. The first is with ANSER, Inc., and is an evolution of a process first used in the reconnaissance evaluation. A second technique being explored by two reserve officers is part of a continuing methodology study.[10] Both are in the early stages.

Summary

Mission-area analysis has been explicitly and successfully coupled to the program/budget formulation process for the RDT&E program. It is too early to state categorically that the same holds true for the total Air Force program, although there has been rapid progress in this direction.

The case for allocating total program resources on a mission basis in the future will depend on the answers to a number of questions. Will the mission-area analysis methodology for the Fiscal Year 81-85 POM cycle be successful? This new methodology is structured like the long-range capability objectives document published by the Concepts Directorate in December 1977 with a focus on orientation, engagement, and implementation tasks. Another unanswered question: Can we fully "missionize" the Air Staff panels? This would allow an even closer link between the mission-analysis structure and the panels—a key element to successfully and permanently tying mission analysis to resource allocation. Can a universal breakout of program elements versus mission areas be agreed upon for use in all OSD/OMB program/budget activities? This would greatly

10. Stanley R. Spector (Colonel, USAFR), and H. Lawrence Elman (Major, USAFR), Progress Report on RDT&E Valuation Program, Directorate of Planning, Programming and Analysis, DCS/Research and Development, HQ USAF, May 1978.

reduce the confusion caused by the current proliferation of mission-area breakouts. And a final question: Can an effective technique for aggregating mission-area analysis results for presentation to successively higher levels of management be devised and implemented? This question is now receiving much attention within the Air Force.

While there remain many challenges, a continued evolution and enhancement of this approach within the Department of Defense is likely. It is a logical way to allow each successive decision-maker to understand the necessary considerations for program prioritization and selection. Although a greater use of the mission-area approach within OSD and OMB is in the offing, there is no widespread evidence of a willingness in Congress to examine program requests from a macro (mission) point of view. In the long term, it is vital that Congress begin examining service programs from a mission perspective if the mission process described is to become the foundation for resource authorization and appropriation decisions. Without such a shift in congressional emphasis, there could well be a rapid retreat to the program-by-program approach since that is how the final tally is now made. ‖

93 Subsystems, Components, and A-109 Policy

Lawrence L. Clampitt
Noel F. Castiglia

Procurement methods in the Federal Government are in the process of evolving yet another step. During the spring of 1976, the Office of Management and Budget (OMB) issued Circular A-109 describing a new major system acquisition policy. This policy implements an acquisition process that begins with the analysis of an agency's missions, the setting of agency goals and objectives to carry out those missions, and the identification of the capabilities required to reach those goals.

Of the 18 agencies and departments that implement their own directives, it was determined that 90 percent of the present major system procurements comes out of five agencies: Department of Defense (DOD), Department of Energy, Department of Commerce, National Aeronautics and Space Administration, and Department of Transportation.

Although A-109 was issued in the spring of 1976, it was the summer of 1977 before each of the five agencies had issued its own definition of a major system by setting dollar levels for the anticipated system procurements. Since DOD procures 50 percent of the Federal Government's major systems, high dollar thresholds are set for DOD systems—$75 million in research, development, test and evaluation (RDT&E) and $300 million in production. The Department of Energy, while not procuring the volume of systems DOD does, anticipates spending $70 to $80 billion on major systems in the next few years; therefore, it sets limits at $150 million RDT&E and $300 million for system life cycle cost.

DOD issued its A-109 implementing policy directive 5000.2 in January 1977. Concurrently, each of the services, Army, Navy, and Air Force, began to identify programs to be procured using the mission-need philosophy. The program need is expressed in a mission element need statement (MENS), which states a requirement in terms of the mission to be accomplished rather than in terms of a specific hardware requirement.

An example of this need was the Navy shipboard intermediate-range combat system. In this project, the Navy specified the type of ship on which the system

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would be installed and the characteristics of the threat to that ship. The contractors were then asked to propose systems to protect the ship from the threat.

Components

This paper addresses the potential effect the A-109 policy could have on components and subsystems. Components are the building blocks from which systems are created; component technology levels determine the performance capabilities of the systems that use them. It is apparent that any course of action and any policy changes affecting components will, in turn, have an effect on future systems.

What do we mean by component? In general, we might describe a component as a functioning item that can be operated and tested, but which cannot readily be broken down into smaller pieces or devices without restricting its functional capabilities. Microwave tubes are offered in this paper as an example of a component. Other examples might include switches, phase shifters, solid-state oscillators or amplifiers, gyros, and torquers. An important characteristic of components such as these, especially active components, is that they must be integrated carefully into the systems they support. In other words, the interfaces involved are frequently complex and critical and often cannot be completely defined and specified in advance. This translates into a clear need for a close working relationship between component supplier and the user, or system developer. It also requires time in the system program schedule.

Twenty years ago most microwave tube development was supported directly by DOD agencies. The industry was young and growing. Advances in the state-of-the-art were in evidence on all fronts. Anticipated system needs were translated into component performance requirements by agency laboratories which, in turn, sponsored component development. Where successful, these components were offered both by the sponsors and the developers to systems designers, who proposed systems to be built around whatever components were available.

The weapon system procurement approach, established in the 1960s, placed more complete responsibility for the selection and full development of needed components with the system contractor. Direct development support for microwave tubes by service laboratories or agencies was reduced significantly and restricted principally to exploratory development. The problem of bridging the substantial gap between feasibility demonstration, the usual outcome of a successful 6.2 program, and full development of a reliable component was left to the prime contractor and often went unrecognized. The results have varied substantially from one program to another. In some cases, critical component development has been recognized, budgeted and scheduled for, and carried out

AD-A069 027 DEFENSE SYSTEMS MANAGEMENT COLL FORT BELVOIR VA F/G 5/1

DEFENSE SYSTEMS MANAGEMENT REVIEW. VOLUME 2, NUMBER 2. SPRING 1--ETC(U)

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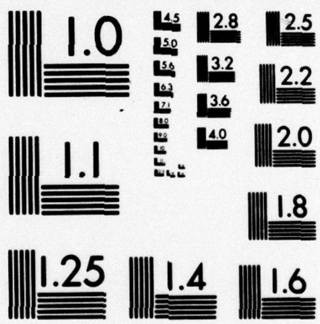

MICROCOPY RESOLUTION TEST CHART

successfully. In other instances, particularly when not adequately recognized, component development has been incomplete and late, causing expensive program delays and degraded system performance and reliability.

One result has been the decree that only "available" components will be used in some programs—that no component development will be permitted. This has not solved the component problem, however, except in those cases where performance requirements were altered to fit proven devices. In this case, "available" components came to mean those components that suppliers would promise to develop using their own funds, supplemented with modest, nonrecurring engineering support from the system contractor. Component suppliers, at least in the case of the microwave tube industry, must bear their share of the responsibility for "over promising" in the existing competitive environment.

Late delivery by the low bidder and a legalistic approach to interface problems (rather than a team effort to solve them) represent no bargain to either the prime contractor or to the ultimate customer—or to the tube supplier, who is pinched financially in the process. Establishment of competitive, multiple sources of supply has not solved this problem when state-of-the-art components have been involved.

Recently, there has been an increased sensitivity to the component development problem on the parts of both service agencies and system contractors. An effort, not always successful, has been made to provide more advanced development and engineering development support for components. Although the pronouncements about increased R&D support remain in evidence, budget-cutting actions in the electron device area speak louder than words.

How will OMB Circular A-109 affect the component supply process? This will clearly depend upon its interpretation and implementation. The opportunity exists for eliminating some of the present component problems, but at the same time the component field could be permitted to lose additional capability.

To provide an appropriate plane of reference, we should consider certain key elements of A-109.

- *Budgeting.* OMB Circular A-109 highlights mission area budgeting and calls for all R&D budgeting to be broken into the following three categories: (1) technology base; (2) support of alternative system design concepts to accomplish each mission need; (3) full-scale development of the selected system.
- *Subsystem (Component) Development.* A-109 (Paragraph 11j) and OFPP Pamphlet No. 1, dated August 1976, state that subsystems (reference is also made to components) are not to be "fully developed" until such subsystem (component) is identified as a part of a system approved for full-scale development. The following qualification is added: "This restriction

> is neither meant to inhibit the demonstration of new and innovative technology advancements nor to inhibit the development and testing of components which will have a common applicability to several major systems. Agency heads may authorize an exception to the prohibition of full-scale development...[of]...long lead time items that fulfill a recognized generic need...."

Let us examine the potential problems. First is one of schedule. If "full development" of a component is defined as 6.3 and 6.4 (advanced and engineering development) effort and is not initiated until the system to be fully developed is selected, the 2-to-5 years required for the development of a state-of-the-art component may pace the entire system schedule, a potentially dangerous and costly situation. Also undesirable would be the failure of an advanced system to survive the competitive demonstration and evaluation phase simply because its performance was dependent on a critical component whose development had not been carried far enough.

If the demonstration of competitive approaches involves operational evaluation of candidate systems or subsystems, as it should, critical component development must be carried significantly beyond that normally achieved in the feasibility demonstration resulting from a typical exploratory development program. The critical need is to carry out this advanced and engineering development effort on components early enough to have them ready for the demonstration and evaluation phase; and to be certain that fully developed, reliable components are available for use in the system selected for full development and production. We should next examine the roles and responsibilities of all agencies and contractors involved to see that this does happen.

DOD Agencies and Laboratories

The problem is one of *defining* the component technology base needed and then *selling* and *defending* the budget to support it. Although the detailed performance characteristics of many components will not be defined until specific system approaches are selected, many other component requirements are determined by mission needs. Microwave tubes suitable for electronic countermeasures applications are one example; there are many types of systems carried on many types of platforms. The frequency spectrum and types of threats are known well enough to define general microwave tube performance needs. If these needs exceed available component performance capabilities, there should be a clear case for technology base work in the area. Guidance from systems organizations as to needs, and component houses as to feasibility, should be solicited to aid in defining more specifically the objectives of such work.

Another important facet of maintaining an adequate technology base is the maintenance of component *capability*. Again using the microwave tube industry as an example, it is relatively mature and static in the sense that it is no longer growing, and most of its end product goes to DOD. The reduction in R&D support and lack of growth over the past decade has reduced the number of companies in the industry and contributed to the departure from it of many engineers and scientists. Recognition of this problem has triggered some recent action by DOD to assist in rebuilding the capability needed to satisfy the continuing demand for improvement in component performance.

If, as A-109 contends, technology base funds are not to be used to support the early phases of specific system development, as may now be the case, there should be resources available to support needed development of materials, devices, and components, as well as a study of system and subsystem concepts. The role of DOD in maintaining and managing these technology base resources will be vital.

Systems Contractors

In addition to the need for great breadth on the part of systems contractors in examining and analyzing mission needs to determine suitable approaches, there will also be a need for considerable depth to assess the component performance capabilities that are feasible, and to determine the risks involved in making use of such components where state-of-the-art advances are involved. Often, this depth will not exist within a system company or division, making teaming arrangements an effective means of bringing the needed capability to bear on the problem. It is important to stress early a critical and objective examination of the pacing component capability questions rather than simply to solicit competitive proposals.

There often will be a need for advanced product development of components to support an effective demonstration and evaluation of competitive system approaches. If an adequate technology base has been maintained, it should be possible to tailor components to satisfy a specific system performance requirement within this phase of program schedule and within its budget. Finally, if "full" development of components is to await the decision for full development of the selected system, the performance demands must be kept consistent with the schedule and budget allocations for component development. It would appear that A-109 should encourage use of standardized components, since competitive system approaches should be evaluated on the basis of their ability to satisfy an overall mission need, rather than on small but expensive performance features or gimmicks.

Component Suppliers

In many respects the role of the component supplier is seen as becoming more complex and difficult under the application of A-109, much as it became more complicated under weapon system contracting with its several layers of subcontractors or customers. The effective use of teaming arrangements in cases where technology advances are involved will place emphasis on the effective marketing of capability rather than on hardware. Realism and objective analysis should be demanded by the system contractor and furnished by the component supplier/team member.

The component industry must continue to play its role in maintaining the needed technology base. As is already the case, component independent research and development investment can be used to show the basic feasibility of new device or component design concepts that may lead to funded exploratory and advanced development work. In some cases, component industry independent development support may be adequate to demonstrate performance feasibility in support of competitive system demonstration and evaluation. If significant advances in performance are required, however, independent research and development resources would be inadequate, and contract funding would be needed.

Subsystems

As noted earlier, Circular A-109 leaves the definition of a major system up to each agency involved. The DOD has defined a major system acquisition program in 5000.1 (January 18, 1977) as "...programs involving an anticipated cost of $75 million in research, development, test and evaluation (RDT&E) or $300 million in production...." By the DOD definition, then, any equipment required to be procured by DOD that does not meet these guidelines, or items that are generally developed or procured by a major DOD prime contractor, are either non-major systems, or subsystems. Subsystems range from landing gears, propellers, and motor generators to radars, displays, computers and electronic countermeasures equipment. For our purposes here, most of the emphasis will be on electronic equipment universally known as "black boxes."

Black boxes are the next-higher-level system building block and are made up of the components discussed earlier. These assemblies are composed of an aggregate of components and may be readily broken down into smaller subassemblies and pieces that are able to be functionally tested. Because of nonstandardization, these are the pieces that often cause logistical nightmares to the user, and can often drive weapon system acquisition cost well over the life cycle cost estimates. In the past 20 years, these subsystems have become capable of increasingly greater performance at the cost of increased complexity.

The emphasis on increased subsystem performance with restrictions on volume, power, and weight has made for challenging technical problems in packaging density and reliability for the equipment producer. The performance of a black box is directly related to the quality and performance of the components previously discussed.

Manufacturers have approached development of black box equipment by bidding to performance specifications or by building products that advance the state-of-the-art.

Specifications

The prime contractor or user will prepare an informed, detailed specification, and the manufacturer most often bids fixed-price to this requirement. In the heat of competition, the supplier will frequently be overly optimistic regarding his ability to meet these requirements. Many times, key critical weapon system subsystems are compromised to save vendor cost through "specmanship," or at the expense of reliability and maintainability. This is primarily due to the inability of the user to adequately evaluate the supplier's ability to produce a quality product. In the case of DOD, the procurement regulations are often overly constraining. Sometimes, even though a producer is highly suspect, a small-business certificate of competency forces the procurement to be awarded to him. With A-109 emphasis at the front-end of the procurement, perhaps a more careful and realistic look at both suppliers and costs will be possible.

Products

In the case of product development, the informed supplier anticipates a need through a close working relationship with a prime contractor, DOD laboratory,or agency; and with allocation of independent research and development and bid and proposal funds as his primary flexible resources, he begins to define a new and more capable state-of-the-art, or cost-effective subsystem. Many times, the requirements for these products fade away and the equipment is relegated to "house mouse" status with a great deal of time and effort having been expended with few positive results. Chalking this type effort up to experience is distasteful, and is a loss of valuable resources. Closely related to this drain of resources in the industrial base is the never-ending stream of requests for proposals, white papers, requests for quotations, and verbal requests for detailed paper equipment designs. Most of these fire-drill efforts are counterproductive to both the user and supplier in that they are another waste of valuable resources. The need to focus investment of resources in a productive fashion is overwhelming, especially in light of present funding realities. The effective use of our industries' developmental resources is one of the most important tools in assuring a

keen degree of readiness to meet defense needs. Circular A-109 can have a positive effect on focusing resources at the subsystem level only if mission and technology needs are real and well understood by DOD, associated laboratories, and industry. The communication of valid requirements is one of the most important needs of the defense industry base.

Valid Needs

The examination of alternatives during the concept formulation and feasibility study phase gives industry the flexibility to innovate and to develop new concepts and ideas. Since more funding will be required during the front-end of the procurement process, it is important that adequate funds be provided to the system prime contractor so that he may, in turn, fund key subcontractors. Since the examination of many more alternatives is necessary, the smaller suppliers, unless adequatly funded, will begin to lose more of their present resources, further constricting an already pressured business base.

Not all needs should be structured in the same depth as a mission element need statement; however, both the technology need and the equipment need should be related and validated to a MENS to assure industry that a truly valid requirement exists. By reducing the number of false starts in the procurement process, A-109 should basically have a cascading, positive effect on the allocation of resources at the subsystem level. Today, many more requirements exist than there are funds available to fulfill them; the MENS or mini-MENS could reformulate these requirements in a meaningful way.

Increased Teaming

One of the more important effects of A-109 is the possible increase in the number and variety of teaming relationships with prime and subsystem contractors due to the breadth of mission-oriented procurement. The subcontractor must understand the need or requirement in sufficient depth to be able to assess the probability that a particular prime contractor will win the overall program. This is very important, because once the subcontractor is "locked in" on a long-term basis to a particular prime, unless his black box has superior technical merit, he will lose further funding if the prime contractor loses. As a team member, the subcontractor prefers that his legal relationship with the prime be flexible enough to allow him to continue pursuing the opportunity when the team prime contractor ends his effort. Under A-109, additional effort by the prime and subcontractor at the front-end of the procurement is necessary to assure a viable, flexible team, since it will be a long-term relationship before any significant funding is realized.

Allowance for Innovation and Manpower Changes

During the next few years, with the increased use of computer-aided design, the number of software engineers and the amount of required software will increase dramatically. This, coupled with the computer processing revolution (IEEE projects a 1000:1 increase in the number of bits per chip during the next 10 years), means that weapon system programs should allow for increased flexibility to accommodate this technology and manpower revolution. Prime contractors should allow for these changes during trade-off studies, during the examination of alternatives, and during the full-scale competitive development.

Since the implementation of policy in the Federal Government takes many years (5 years is a good number), industry will continue to react to presently funded projects in a Pavlovian manner, as it has in the past. However, should the A-109 philosophy continue to evolve and be supported by the Congress and DOD, the component and subsystem industry will need to begin planning new resource investment strategies in order to more completely understand and contribute to the requirements of the marketplace. The subsystem and component industry is just now realizing that A-109 exists and that it will have a direct effect on its business posture and organizational structure. *Its effective implementation* will require increased spending by both government and industry at the front-end of the procurement cycle. This investment should enhance the technology base and increase the application of this technology in developing innovative system concepts, especially during the examination of alternatives.

Specific mission needs will tend to focus efforts on near-term problems while technology base needs are directed toward longer-term solutions. Technology needs represent one of the most sensitive areas of the five-year development plan, since much of the exploratory development work is not program-oriented and will sometimes lack solid definition. This, in the past, has made the technology base more vulnerable to funding cuts than the more equipment-oriented projects. The technology need is most important and should provide for breakthrough opportunities in different fields through examination of technologies that cross the functional mission areas.

It has been suggested that technology transfer between companies kills incentive, stifles creativity, and destroys competition. The real transfer of technology is in the minds of men and remains with them as they cross the borders between industry and government laboratories. Manufacturing know-how is the most important part of technology and is the most difficult to transfer, as DOD has found out through experience in the invitation for bid process, and industry through the licensing process. The A-109 acquisition strategy should not be modified to stifle the interchange of concepts that already takes place through technical articles and market intelligence in the name of technology transfer and competition.

The equipment suppliers need a high level of exposure to valid mission needs to better understand DOD requirements. The service exploratory development groups should spend more time making technology projections, and relating these projections to applications and needs with an investment strategy to adequately focus industry and laboratory efforts. Since application of new technology breeds innovation at all levels of equipment developments, this technology-need focus is important. It should be developed with industry, and should be adequately funded.

On the component level, it is important to begin advanced and engineering development effort early, thus ensuring that fully developed, producible, reliable components are available for use in the weapon system chosen for full-scale production. Both DOD laboratories and system prime contractors have the responsibility to assure that adequate funding is available to achieve this goal.

We recognize that A-109 applies to *major* systems, and that many smaller systems and subsystems using components will be produced as they are now. The implementation of A-109 can, however, have a significant impact on the technology base, on component industry capability, and, in turn, on subsystems as well. The challenge we all must face is to make this impact a positive one. ‖

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